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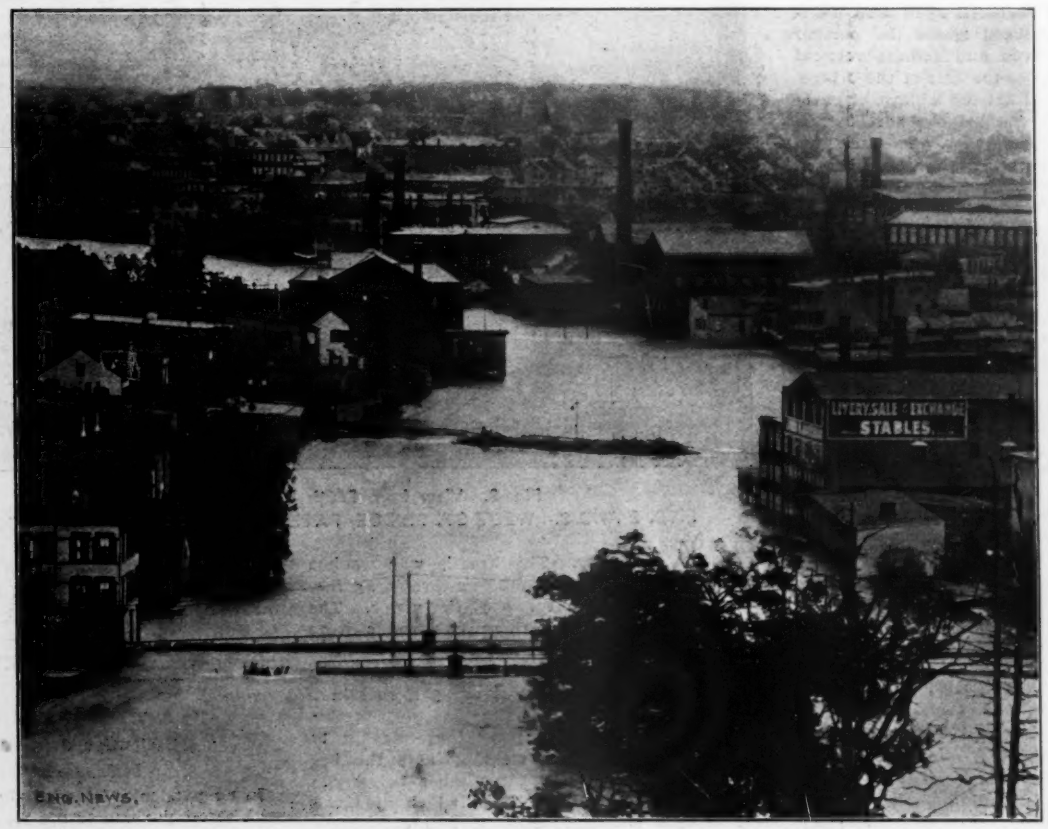
TABLE OF CONTENTS

	Page
LEADING ARTICLES:	
Flood Damage to Bridges at Paterson, N. J. (illustrated)	377
Some Observations on Street Pavements (continued from page 371). S. Whinery, M. Am. Soc. C. E.	378
Tests of Steel for Electric Conductivity with Special Reference to Conductor-Rails (illustrated). J. A. Capp	381
The Soft-Ground Tunnel Under the Regents Canal; Whitechapel & Bow Ry., London (illustrated)	383
Annual Convention of the American Society of Municipal Improvements	384
Charles Ezra Greene (with portrait)	387
The East River Division of the Pennsylvania R. R. Tunnel at New York City (with two-page plate and profile)	393
Methods of Making Annual Inspection of Bridges and Culverts	394
Annual Convention of the Association of Railway Superintendents of Bridges and Buildings	396
Rebuilding the "Flow-Line" Bridge at Kansas City (illustrated). J. A. L. Waddell, M. Am. Soc. C. E.	397
Improvement of Railway Terminal Facilities at St. Louis, Mo.	401
Municipal Electric Light Plant at Orillia, Ont.	402

	Page
EDITORIAL COMMENT.—The Passaic River Floods and the Bridges at Paterson—Methods of Flood Control for the Passaic—The Failure of Concrete Steel Bridges—The Physical Examination of the Motormen on the New York Interborough Railways—Profits from the New York Electric Subways not Accounted for to the City—The Coroner's Verdict and the "Expert" Testimony on the Derrick Accident at Lincoln, Ill.	388, 389
EDITORIALS:	
Recent Revelations Concerning Trust Financiering	389
Further Light on the New York 1,000-Ton Barge Canal Project	390
A Court Decision on Patents on Aluminum Production Processes	390
LETTERS TO THE EDITOR.—A Method of Making a Blue-Print from a Blue-Print: W. Allen Bartels—The Advisability of Using Brown-Print Paper Instead of Blue-Print Paper for Copying Drawings: "Engineer"—More About the Tar and Cement Joints for Vitrified Pipe at Atlantic City, N. J.: E. W. Branch and Kenneth Allen—The Design of the Seventh St. Eye-Bar Suspension Bridge at Pittsburg, Pa. (illustrated): Chas. Worthington and G. Lindenthal—An Alternative Plan of Pile Supports for the Pennsylvania R. R. North River Tunnel (illustrated): J. W. Reno	391, 392
ENGINEERING NEWS OF THE WEEK	402

FLOOD DAMAGE TO BRIDGES AT PATERSON, N. J.

The remarkable rainfall of Oct. 8 and 9 over the central Atlantic Coast region, reported in our issue of Oct. 15, produced high flood waves in most of the rivers in that region. At a number of points the flood level was higher than for any time within fifty to one hundred years past. Such was the case at Paterson, N. J., on the Passaic River, a stream which drains nearly 1,000 sq. miles of territory in northern New Jersey, west of New York city. The conditions at this point are of peculiar interest, none the less so because only last year there occurred a flood which exceeded all records since 1810, and did great damage to low-lying districts and to bridges. The destruction, wholly or in part, of a number of bridges during the most recent flood offers some noteworthy features.



THE PASSAIC RIVER AT PATERSON, N. J., DURING THE FLOOD OF OCTOBER, 1903. (VIEW DOWNSTREAM FROM GREAT FALLS.)

The flood of last year (February-March, 1902), was brought about by a period of warm weather, accompanied by rain, which carried off the accumulated ice and snow on the ground. A good part of the drainage area of the Passaic is hilly, and the run-off is relatively rapid. Thus in a report on the 1902 flood (contained in the Annual Report of the State Geologist of New Jersey, for 1902), Mr. C. C. Vermeule estimates that during eight days from the time the Passaic reached the bank-full stage, the discharge over the Dundee dam (7.5 miles below Paterson and at the head of tide-water), amounted to 86% of the total of the precipitation during that period plus the rainfall equivalent of the accumulated snow and ice. The flood of last week was not aided by snow, or ice, or even any accumulated saturation of the ground in the drainage area, but resulted from a very heavy and unusually concentrated rainfall. A steady downpour of rain, beginning on the morning of Oct. 8, continued for about 30 hours. The New York office of the U. S. Weather Bureau registered a total fall during this period of 10.04 ins. Another rain gage at a station maintained by the East Jersey Water Co., at Little Falls, N. J., located on the Passaic River, only a short distance above Paterson, recorded a depth of 14 ins.! It is hardly probable that this latter precipitation was reached over the whole drainage area of the Passaic, but it is certainly probable that the average over the Passaic valley was not less than 10 ins. More than half of this, no doubt, flowed over the dam at Dundee during the eight or ten days following.

The flood which followed this rain exceeded that of the previous year at all points. At Paterson it reached a high-water level some 36 ins. above that of 1902. The maximum discharge of the stream, it will probably be found, fully equals or exceeds the estimated maximum of the flood of 1810 (25,000 cu. ft. per sec.). In order to appreciate the effect of this flood discharge on the bridges across the Passaic at Paterson, the condition of the river channel at that city must be understood.

At its entrance into the city of Paterson, the river falls over a rocky wall some 70 ft. high, passes through a short gorge and then flows with moderate slope until, five miles below the falls, it reaches the backwater from the Dundee dam. The latter forms a capacious pool-like channel for two miles above, but the preceding section, where the river passes through the city of Paterson, is quite inadequate to carry even moderate freshets. The contraction of the channel by bridge piers and other obstructions, and its gradual silting up from the discharge of sewers, etc., have reduced its capacity considerably below that which it had originally. In consequence, a flood of any volume rapidly piles up below the falls, and overflows into a strip of low-lying land along the river bank. However, as this land is solidly built up with mills and dwelling houses, no appreciable relief is afforded the flood here. In the river channel itself, the obstruction rapidly increases as the water passes the springing line of the bridge arches. Figs. 2 to 6, taken when the water was 3 to 4 ft. above normal, indicate how small is the margin up to this point. Once the water has risen above the springing of the arches, the increased damming effect of the bridges and the drift which they accumulate is such that a considerable fall occurs across each bridge, raising the flood-level behind it by that amount.

Within the city of Paterson, from the falls to the backwater of the Dundee dam, there were some ten bridges across the river. Two of these were railroad bridges, the others carried city streets or roads, one or two of them with trolley tracks. Of these bridges only two, besides the railway bridges, were in service condition after the flood. One of these was a relatively high-

level bridge; the other, the Main St. bridge, had been completely overtopped by the flood.

A view of the river in flood is shown on the preceding page. The portion shown is a short distance below the falls, and the bridge in the foreground is the first bridge below that point. Three bridges are included in the field of view of Fig. 1: the West St., Main St. and Arch St. bridges, respectively. All these are low-level bridges, and all were completely submerged. The photograph reproduced in Fig. 1 was taken some 6 to 12 hours after the maximum height of the flood, which occurred in the night from Oct. 10 to Oct. 11, about 60 hours after the beginning of the rain. The Arch St. bridge was still wholly under water when our photograph was taken; the two bridges above were awash at the highest point of the roadway.

The condition of these three bridges after the flood is portrayed by the photographs Figs. 2 to 7, taken on Sunday, Oct. 18, just a week later than the photograph, Fig. 1. The water was still several feet above normal when Figs. 2 to 7 were taken, and was running with a strong current, as the pictures indicate. The West St. bridge was a Melan concrete-steel arch structure of three spans, each about 90 ft. in the clear. It carried a double-track street railway in the middle and two sidewalks. It was built in 1897 and was fully described in Engineering News of March 16, 1899. The structure passed through the flood of 1902 without damage, though the water reached the roadway level. It was less fortunate in the recent flood, as Figs. 2 and 3 indicate. Two of the three spans fell, for a width of about one-third of the total width of the bridge on the upstream side, while the southern span was uninjured. In the two damaged spans the portion that went out left an even and definite vertical plane of parting, parallel to the axis of the bridge. It seemed as if there had existed a natural parting at this point which enabled one part to fall without affecting the remainder. In fact, we learn that the concreting of each arch rib was done in three longitudinal sections, each representing a separate day's work; since there were no lateral tie-rods between the curved I-beam ribs, the adjacent sections were held together only by the adhesion between the two batches of concrete.

This bridge was faced with brownstone finish over the concrete face walls. As may be seen in Fig. 3, the facing was not injured in the undamaged span. Part of the cinder filling over the arch ribs was washed out, but the portions of the arches which remain standing appear to be uninjured. The cause of the failure is not yet determined. It has been suggested that the northerly abutment failed at its upstream end, by undermining; this abutment was not piled, and, moreover, had a sewer passing through it. However, the remaining width of the span resting against this abutment appears sound.

The Main St. bridge after the flood is shown in Fig. 4. This is a three-span steel arch structure built within the last few years. The railings of this bridge were destroyed, and the sheet-metal cornice damaged. Otherwise the bridge was uninjured, and it was the only bridge near the center of the city which carried road traffic after the flood. (The downstream sidewalk of the West St. bridge was put into service for pedestrian traffic.)

The Arch St. bridge, next below, was completely wrecked, as shown by Figs. 5 and 6. It was a three-span concrete (-steel?) arch bridge built a year ago to replace a structure carried out in the 1902 flood. Apparently the northerly river pier was undermined by the current and dropped the northerly span, which broke in two at the crown. The central span was also totally wrecked by this failure, and the third span appears to be seriously cracked. Fig. 7 gives a better view of the fallen end span.

The other bridges which were carried out offer fewer points of interest. They were all of them truss bridges of light construction, and we need not consider their failure at present. One case, however, deserves mention as pointing a direct moral. The Broadway bridge, which crosses the river some three miles below, is a five-span deck truss bridge, which is at such a level that the flood barely submerged the lower chords. Immediately adjoining it on the upstream side a trestle crossing had been built to carry a trolley line across the river. This trestle was washed out by the flood; its wreckage was thrown against the bridge and tore out two of the spans. The trusses and roadway of these two spans were carried clear of the bridge, and their anchor-bolts tore out large portions of the piers. Fortunately the seats of the adjoining river span remained intact.

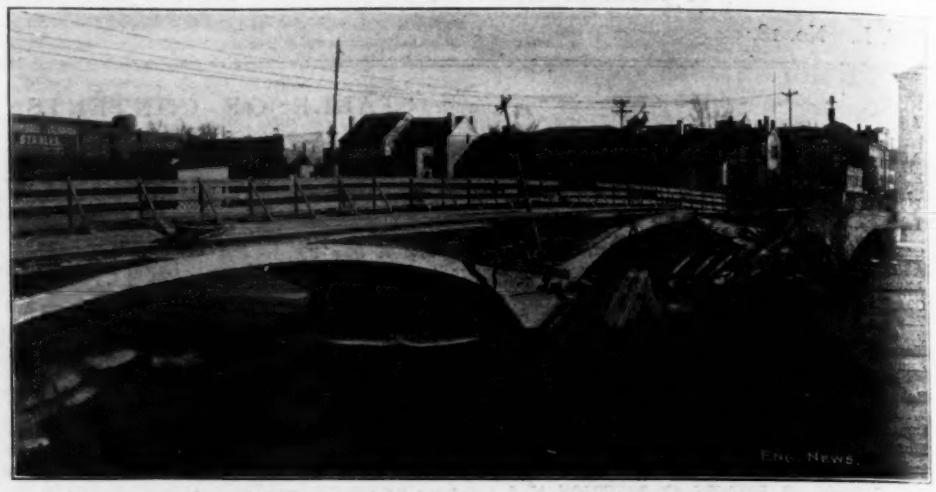


Fig. 2. View from North End, Looking Downstream.

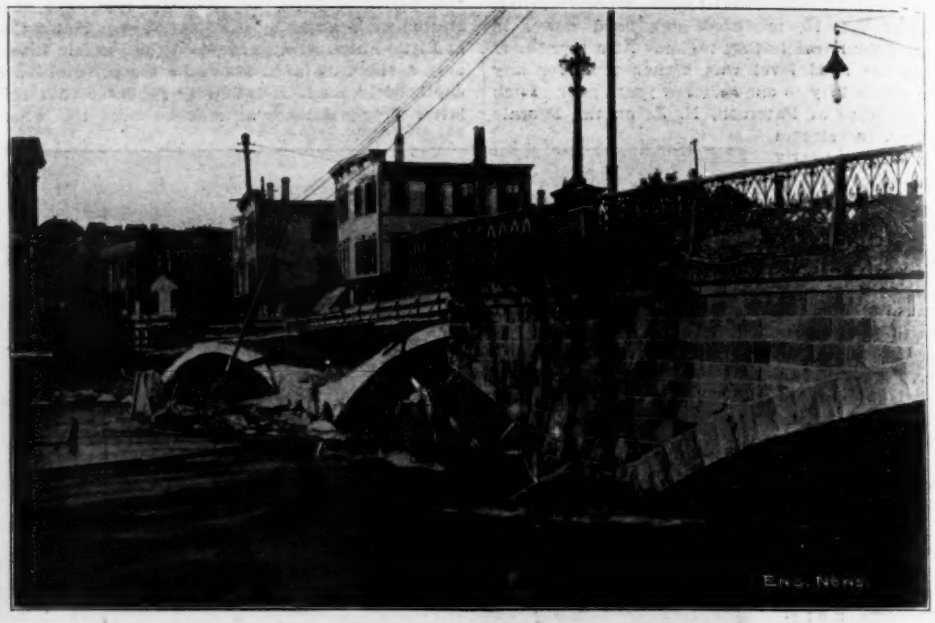


Fig. 3. View from South End, Looking Downstream.

FIGS. 2 AND 3. WEST ST. BRIDGE, PATERSON, AFTER FLOOD OF OCTOBER, 1903.

In connection with the preceding, relating to the bridges at Paterson, we may note the behavior of a bridge some three miles below the Dundee dam, at Passaic, N. J., which, like the three bridges shown in Fig. 1, was completely overtopped by the flood. This structure, the Garfield bridge, is shown in Fig. 8. It is a three-span steel plate girder highway structure, with suspended floor beams and concrete floor. This bridge came through the flood undamaged except for a dent in the sidewalk railing at the upstream side. It is probable that the rapidity of current and volume of water at the crest of the flood were fully as large here as at Paterson. There was also, no doubt, quite as much drift and wreckage brought to this point as came against the upper bridges at Paterson, and the damming effect of this plate-girder structure appears from the flood-marks to have been quite as great as, or even greater, than that of the low level arch bridges at Paterson. The solid floor and girder construction of the Garfield bridge must be credited with much of the excellent resistance of the structure. The relative share of the strength of foundations and superstructure in the behavior of the different bridges described cannot be safely estimated in advance of a thorough investigation of the structures, and it is quite possible that even this might throw no further light upon the question.

SOME OBSERVATIONS ON STREET PAVEMENTS.*

IV.

By S. Whinery, M. Am. Soc. C. E.

(Continued from p. 371.)

Resistance to Traction.

In no particular of equal importance connected with street pavements are we so completely without satisfactory modern data as in that of the actual and relative resistance to traction of the several varieties of street pavement, or of any one kind of pavement under various conditions of repair and cleanliness.

Considering what an important factor is tractive resistance in determining the relative economic value of the different pavements, it is surprising that so little has been done in this field. Almost every writer upon pavements quotes the scant and unsatisfactory information we now have, which seems to show that its importance is not unappreciated. But if we examine the foundation upon which most of these oft-quoted data rest we shall find that, judged by the standards

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we are accustomed to apply to experiments and tests in modern industrial research, it is very unsatisfactory. The results reached by Morin, nearly a century ago, are perhaps most frequently quoted. Considering the time and the conditions under which his work was done, it deserves great praise. But the apparatus used by him was somewhat crude, and the absence of full information about the character of the pavements experimented upon, their exact condition of repair, the cleanness of their surfaces when tested, and other essential information, renders the results reached by him of comparatively little value for application to our latter-day pavements and conditions. Most of the other experiments that are of record are fragmentary, inasmuch as they usually relate to but one case, or at best to a few isolated cases, and in most of the records there is such an absence of detail and of information relating to the condition of the pavements tested, as to make them of comparatively little value in a systematic study of the subject at this time.

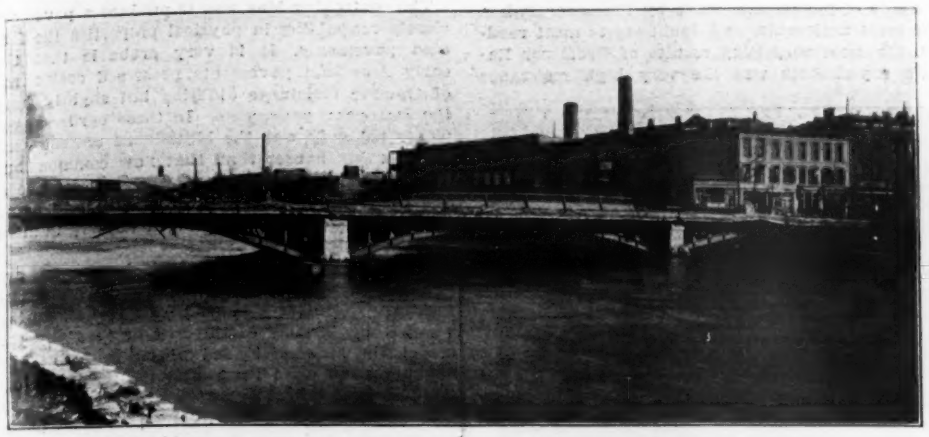


FIG. 4. MAIN ST. BRIDGE AFTER FLOOD, LOOKING DOWNSTREAM.

It is highly probable that a full and accurate determination of the tractive resistance of our present-day pavements would show that the coefficients of resistance now commonly accepted are very far from being correct. As an example, may be instanced the commonly-used coefficient for the resistance of asphalt pavement. Some quite recent trials have given results which seem to indicate that the later American asphalt pavements offer a much greater resistance to traction than the earlier, but meager, trials upon European pavements (which have heretofore been relied upon) led us to believe. This is not surprising since the composition and physical character of the two pavements are materially different.

It may be safely predicted that when engineers come to apply to the economics of street pavements the careful analysis and reasoning that has long been characteristic of their work in other departments of transportation, resistance to traction will be considered one of the most important elements that enters into the problem, and there will be a demand for reliable data upon the subject. It is, therefore, of great importance that such data should be accumulated and made available to the engineer.

To be of substantial value it is essential that the recorded results of dynamometer determinations shall not only be accurate, and stated in common units, but that all the attendant conditions shall be recorded in uniform terms.

It seems, therefore, desirable and important that the investigation shall be undertaken and carried out in accordance with a well designed plan, and upon a scale that will make the conclusions arrived at of general application in American cities. For this reason it is unlikely that the work can be undertaken and satisfactorily carried out by any one individual, or by one isolated city. The design and construction of the necessary apparatus will require time and money, and the actual work of making the determinations of tractive resistance on a sufficient number of streets and in a sufficient number of cities will occupy no small amount of time and will involve a very considerable expense.

It would, therefore, be advisable that the work should be taken up by the Government or by some one of our scientific or technical associations, competent to deal with the subject in the proper manner. Unfortunately, our engineering societies are not prepared to enter upon and conduct original investigations of this character, and this particular branch of inquiry does not seem to fall naturally within the province of any existing department of the national government, though it is so nearly related to the work of the Office of Public Road Inquiries of the U. S. Department of Agriculture that the head of that office might possibly be induced to undertake the investigation.

There seems little more to be done at this time than to call attention to the great importance of the matter. When this importance becomes more generally appreciated, it may be confidently hoped that some way will be found to carry out the investigation.

The essentials of a system of determinations of traction resistance of street pavements may be briefly summed up as follows:

(1) The design and construction of the necessary apparatus. None of the devices heretofore used has been up to modern requirements in accuracy, delicacy and reliability of action.

(a) The dynamometer is, of course, the most important part of the apparatus required. Whatever form of dynamometer is employed, it should be accurately sensitive to differences of one pound in the tractive force exerted and should have sufficient range to measure the resistance offered by any variety of pavement to the hauling of a load of not less than one ton over it. Friction of parts should be as far as possible eliminated, and steadiness of action should be secured, so that its index will not be subject to rapid and unimportant fluctuations of readings due to extreme sensitiveness, or to momentum of its parts. It should indicate not only maximum and minimum draft, but should give the total foot-pounds of work done from the beginning to the end of the experiment, so that this total divided by the distance traversed will give the true average resistance.

(b) The apparatus should indicate correctly the degree of roughness of the surface of the pavement and the character of that roughness—whether the irregularities of surface are due to a multitude of small elevations and depressions, as in a newly laid granite block pavement, or to undulations like those frequently found in asphalt pavements.

(c) It should indicate accurately the distance traversed, and the time occupied, so that the velocity of travel may be determined.

Fig. 5. View Looking Downstream.

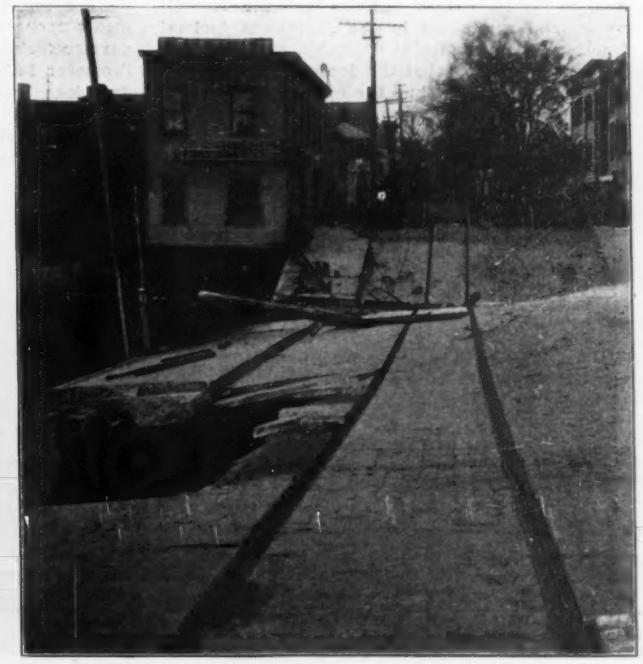


Fig. 6. View of Wreck of Northerly Span.

FIGS. 5 AND 6. ARCH ST. BRIDGE AFTER FLOOD.

(d) It should be automatically self-registering, so that all the observations may be permanently recorded.

(e) It should be so constructed that the load may be varied at will.

(f) Its general form should be such that its results will represent correctly the conditions of the average street vehicle. In other words, its running gear should duplicate the conditions of the ordinary two or four-wheeled vehicle.

(g) It should be capable of using and should be supplied with wheels of various diameters and treads, so that the influence of diameter of wheel and width of tire may be accurately determined.

(h) The whole apparatus should be of standard form, so that it may be duplicated, if necessary, in order that identically similar machines may be built, and after being standardized, may be used in the different cities, and at different times.

(2) Having at hand such apparatus, it should be used under the following conditions and regulations:

(a) The pavements whose tractive resistance are to be determined should be intelligently selected, so that the results may embody all usual conditions. Each kind of pavement should embrace examples of the several conditions of age and repair, from that newly constructed to that approaching the last stages of its usefulness.

(b) The determinations should, in each case, be sufficient in number to give a reliable average.

(c) If the pavement is not level longitudinally, the gradient should be ascertained and recorded, and the resistance determined in both directions.

(d) The tractive resistance of each pavement should be determined under all ordinary conditions of use, such as degree of cleanness, whether dry or wet, etc. The temperature of the air and the weather conditions at the time should be observed and recorded.

(e) The records should be full and definite. Every condition that may affect the result, or deductions therefrom, should be recorded.

(f) Such corrections as may be necessary for friction and inertia of parts of the apparatus should be made.

The form in which the coefficient of resistance shall be stated is not especially important. It is simetimes stated in pounds per ton of load, sometimes as a common fraction, of which the resistance is the numerator and the load the denominator, and sometimes in the equivalent decimal fraction. Uniformity is desirable, however, and the writer suggests that the decimal form shall be generally adopted. Thus the coefficient of resistance of a pavement where it is found that 40 pounds is required to haul a load of one ton would be stated as 0.02.

V.

Tractive Resistance of Asphalt Pavement.

Reference has already been made to some recent determinations of the tractive resistance of pavements that seem to controvert coefficients that have heretofore been accepted as reliable.

In "Roads and Pavements," by Prof. Ira O. Baker (p. 29) are given the results of some determinations of the tractive resistance of a number of kinds of pavements, made by Professor Baker. The most noticeable, and doubtless to most readers, the most surprising results of Professor Baker's experiments was the very high resistance

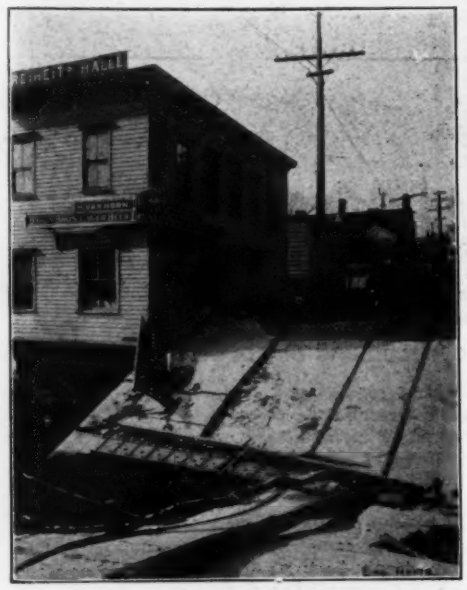


Fig. 7. North End of Arch St. Bridge.

to traction offered by the asphalt pavements embraced in his experiments.

The natural conclusion is that either Professor Baker's results are erroneous, or that the coefficients we have heretofore accepted and used are not entitled to confidence. Such a conclusion is probably not warranted, and it may well be that neither result is erroneous. The earlier experiments upon asphalt pavements in European cities gave coefficients varying from 0.007 to 0.019, while Professor Baker found that the resistance of the American asphalt pavements which he tested gave coefficients varying from 0.017 to 0.035. The fact seems not to be as generally recognized as it should be that asphalt pavements abroad differ materially in composition and physical properties from most of the pavements called by the same name in America, and that the American pavements differ so widely from each other that their coefficient of resistance to traction may vary within wide limits. The earlier asphalt pavements constructed in this country had their origin in the attempt to fabricate an artificial mixture of bitumen and other mineral matters which should closely imitate the composition of the natural rock asphalts used in the construction of asphalt pavements abroad. These efforts resulted in a composition of natural bitumen, sand (silica), and pulverized carbonate of lime, possessing to a large degree the merits of the natural composition of bitumen and carbonate of lime used abroad, and in some respects superior thereto.

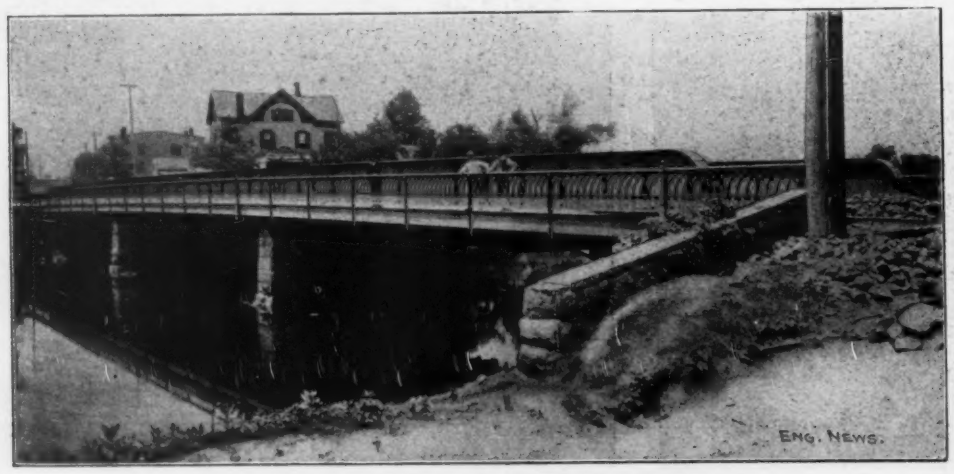


Fig. 8. THE GARFIELD BRIDGE AT PASSAIC, N. J.

The controlling idea was to produce a pavement closely resembling in physical properties the foreign pavements. It is very probable that the early American pavements possessed coefficients of tractive resistance differing but slightly from the European pavements. In these earlier pavements not only was the bituminous cement used considerably harder than that now common, but the quantity of cement used was materially less, and the resulting pavement was much harder and more rigid under travel than is customary in more recent practice.

Those earlier pavements, of which not a few are still in use, were consequently very hard and unyielding, and after a short period of use, during which they became compressed or "set" by the travel, the heaviest loaded wheels made little or no impression upon them, and the resistance offered to traction over their firm and smooth surface was very small. In this respect these pavements compared very favorably with the European asphalt pavements.

It was discovered, however, that the durability of the pavement could be materially increased by making it richer in bitumen and by using a cement of somewhat softer consistency. The long periods of free guaranty and the severe requirements of these guaranties have led contractors to the adoption of a composition so rich in bitumen that the pavements are objectionably soft, particularly in warm weather, and the yielding of their surfaces under the pressure of loaded wheels increases very greatly the power required to haul loads over them. Careful determinations would probably show that the tractive resistance of many of the more recent asphalt pavements, particularly while comparatively new, and during summer weather, is greater than that of any other kind of pavement in use except only cobblestone, but not excepting the best examples of macadam roadway. There can be no doubt that the durability of the pavement has, in this way, been greatly increased, but durability is not by any means the most important requisite in a street pavement, particularly where the travel is heavy. If in these soft pavements greater durability has been secured at the expense of a large increase in the power required to haul loads over them, a serious mistake has been made.

There is doubtless for each street, with its conditions differing from those of any other street, a certain combination of richness in bitumen, and hardness, which, all things considered, constitutes the best compromise between antagonistic qualities. The determination of the best composition to be used to meet the conditions to which the pavement is to be subjected demands the combined judgment and skill of the engineer and the specialist, and in the attainment of this end it is important that the engineer and the contractor shall work in harmony. It is safe to predict that when the whole subject of the functions of a street pavement shall be more carefully studied, the very rich and soft asphalt pavements now being generally constructed will be condemned.

It will doubtless be found advisable in time, in the interest of low tractive resistance, to include in the specifications for asphalt pavement some requirement limiting the plasticity of the surface, and prescribing standards of hardness at stated temperatures. While there can be no doubt among those familiar with the subject that the earlier asphalt pavements constructed in this country were too lean in bitumen to produce the best combination of durability and ease of traction, it may be confidently asserted that in the last few years contractors have gone to the other extreme. When city officials and the public come to realize that these rich and soft pavements require more power to haul loads over them than the ordinary granite block pavement, it is reasonably certain that a demand will be made for a change in this respect.

Supplemental to the determination of tractive resistance of pavements, it is very desirable that we should have a new determination of the frictional resistance of the various forms of vehicles at present commonly used on our city streets. The dynamometer apparatus used for determining tractive resistance could doubtless be utilized for the purpose.

and a return to a composition which, while perhaps a little less durable, will offer less resistance to travel.

The present practice of exacting from contractors long free guaranties is largely responsible for the present tendency to lay very soft pavements in order to increase their durability. The contractor can not be blamed for attempting to meet the public demand for pavements of great durability, or for efforts to reduce the cost of maintenance during these long free guaranty periods.

Experience indicates that attempts to secure the requisite hardness, combined with maximum durability, by the use of much harder asphaltic cements will not prove successful. A certain degree of plasticity and softness seems necessary to prevent the chipping, cracking and crumbling of the pavement, and we must probably depend upon some method of securing an unyielding surface while continuing to use cement of about the consistency now employed.

The substitution of coarse angular fragments of hard stone for a part of the sand that now constitutes the bulk of the pavement seems to offer a promising prospect of improving the present standard construction of asphalt pavements. A pavement composition in which a large part of the mass is composed of such angular fragments would obviously offer greater resistance to the movement of the particles of which it is composed, among each other, than one composed wholly of grains of rounded sand. With cement of the same hardness and a composition of the same richness such a pavement should yield less under loaded wheels, and the resistance to traction should thus be reduced.

Recent experiments with construction of this character seem to confirm this conclusion, and they will doubtless be watched with a great deal of interest.

VI.

The Economic Value of Low Tractive Resistance.

Municipal engineers might study with great profit the efforts made by our modern railways to reduce the tractive resistance of trains, in order to increase the maximum train load, and to otherwise decrease the cost of transportation; and the favorable financial results that these efforts have achieved. Large sums of money have been expended upon nearly every important line of railroad to reduce gradients, flatten curves and improve the track, and these investments have proved eminently profitable. Of course the wide difference between the conditions of railroad transportation and those of street transportation makes any direct comparison impossible, but important lessons from the one may be applied to the other.

In the case of the railroads, the increased profit resulting from these improvements has been due to the greater maximum train loads that can be hauled over the road, the decreased resistance to traction on all loads, and the decrease in expenses of maintaining rolling stock. These ends can also be attained in street transportation by improving the character of pavements, and the only question is, will the resulting economy, and consequently profit, be sufficient to justify the additional investment that superior pavements may involve? In the final analysis the question of street pavements is a question of profits, and while other considerations may influence the choice of a pavement, the main one must generally be the effect upon the cost of street transportation. As the amount and character of the travel on different streets varies within wide limits, the problem of the intelligent engineer must be to select that character and quality of pavement which, under the conditions prevailing on a given street, will yield the best return upon the money invested, to the public and to the local residents. This is obviously a simple business proposition requiring no argument. But in the present condition of our knowledge, the difficulty that confronts the engineer is that of determining by scientific methods, such as he is accustomed to employ in other professional work, what amount of expenditure is justifiable, and will result in the greatest aggregate benefit to the public. One of the most important factors in the problem is the relative cost of transportation over the several varieties of pavement, and to determine this we must know the coefficient of resistance that the pavement offers to the movement of loads over it, and the economic value of this resistance. In the case of the railroad we know that there is a direct relation between train resistance and coal consumption, and it must be equally true that there is some relation between tractive resistance on pavements and the quantity of food consumed by horses. This is a fact that we are apt to overlook in dealing with street transportation. We are apt to reason that if a horse can haul a certain load without undue exertion, nothing is to be gained by decreasing that exertion. In other words, while conceding that the coal consumed by a locomotive bears a direct relation to the work done, we assume that it costs no more for a horse to haul two tons than to haul one ton, provided the latter load does not overtax him. But upon more careful consideration we know that this cannot be true. We know that in a mechanical sense a horse is a machine for converting certain kinds of fuel into power, and that like the locomotive the power produced is in proportion to the fuel consumed. Consequently every additional foot-pound of work done calls for an additional quantity of fuel, or in the case of the horse, food. If this be so, it must follow that every additional pound required to haul a load over a pavement, whether that load be full or light, must involve some additional expense.

It may be urged, and it is doubtless true, that a certain amount of exertion conduces to the physical welfare of the horse, but the act of traveling, without drawing any load, must supply all requisite exercise, so that this consideration may be disregarded. While it must be conceded that we cannot apply to the horse as a prime motor the same rigid mechanical laws that we use in dealing with the steam engine, it must on the other hand be admitted that there must be some tangible relation between the work he does and the food he consumes. The mechanical equivalent of a bushel of corn or oats converted into power through the horse, is a question too abstruse for us at present, but it is not impossible of solution, and we may expect the future engineer to deal with it intelligently. For the present, however, we must forego its consideration and confine ourselves to the question of the effect of tractive resistance upon the maximum loads that a horse is capable of hauling. Even here, we are at present without the data necessary for accurate consideration of the problem.

A small part only of the vehicles drawn over streets carry loads that approximate maximum loads. From such street-census data as are available, supplemented by common observation, I think that about one-tenth of the vehicles passing over city business streets may be considered as carrying full loads. The full load on a good pavement may not be generally possible, because the vehicles may have to pass over inferior pavements, or over unpaved streets for a part of their routes, and the maximum load is fixed by that part of the route offering the greatest resistance, and consequently it is not always possible to realize all the benefit that should result from good pavements. But it seems fair, in comparing the merits of different pavements, to assume that they can be utilized entirely for the maximum loads they will permit to be hauled over them, and I do so in what follows.

It is probably fair to assume that the average length of haul in our cities is one mile, and we may then assume further that each team would haul eight loads per day. If the average travel over the street amounts to 300 vehicles per day we may consider that one-tenth of these, or 30, carry full loads, and we will further assume that the cost of a two-horse team is $3.50 per day. The coefficient of resistance of a good macadam pavement is about 0.03, and that of a good brick pavement is about 0.015. In practice, however, we probably should double these coefficients, in computing practical loads. The tractive power of a horse in daily work is about 125 lbs. Deducting the weight of the vehicle (say one ton) we may therefore compute that a two-horse team would haul eight loads of one ton each over the macadam pavement, or eight tons per day, at a cost of $0.437 per ton, and that the same team would haul eight loads of three tons, or 24 tons per day, over the brick pavement, at a cost of $0.146 per ton. The difference in favor of the brick pavement is $0.291 per ton. The 30 full-loaded vehicles with loads of three tons each would therefore represent a saving of 90 × $0.291 = $26.19 per day, and counting 310 days per year, the total saving for the year would be $8,118.90. Assuming the pavement to be 30 ft. wide, one mile of it, with intersections, would contain not more than 20,000 sq. yds. If the macadam pavement cost $1.10 per sq. yd. and the brick pavement cost $2.15, the one mile of brick pavement would cost 20,000 × $1.05, = $21,000, more than the macadam pavement, and if our figures are correct, this would be more than returned in the first three years' use of the pavement by the one item alone of the larger maximum loads possible on the brick pavement. These figures, or rather the assumptions upon which they are based, may not be accurate, and do not embrace a number of factors necessary to a fair determination of the relative cost of transportation over different pavements. They are presented simply to illustrate the importance of tractive resistance in considering the economic merits of different pavements, with the hope that such interest will be excited by them as will lead to a rational study of the subject. It is confidently believed by the writer that such a study will lead to the conclusion that in the case of city streets carrying a heavy travel, the economic value of low tractive resistance is a factor of such magnitude that the question of the first cost of pavements may, for this reason alone, be of relatively small importance.

TESTS OF STEEL FOR ELECTRIC CONDUCTIVITY, WITH SPECIAL REFERENCE TO CONDUCTOR-RAILS.*

By J. A. Capp.†

For certain classes of electric railways a steel conductor is preferable to the older and more commonly used overhead trolley-wire. The third-rail presents a rather better appearance, because of the absence of an overhead structure; it is easily installed, cheaply maintained, presents a large area for conducting and collecting the current, and is particularly well adapted for high speed and heavy service. With costs calculated on the basis of equal conductivity in rail and trolley-wire, the third-rail construction is cheaper than the overhead trolley. But the average interurban road will use a trolley-wire of considerably less conductivity than would be obtained with the smallest size steel rail (about 60 lbs. per yd.) that would ordinarily be used, and here the first cost of trolley construction would generally be less than that of the third-rail. While no third-rail installation has been in operation long enough to give figures of value, it would appear that the cost of maintenance of the third-rail construction should be less than that of the overhead trolley. This consideration, together with that of sightliness and adaptability (particularly in the case of terminals, yards and very heavy or high-speed service), will frequently offset the higher cost of the third-rail construction and make it the preferable means of conducting the current from the generator to the car-motor.

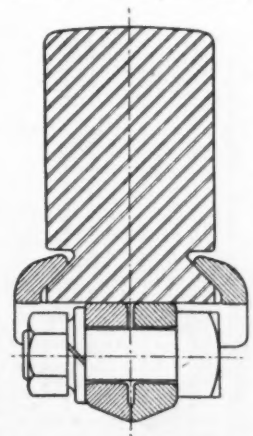


Fig. 6. Cross-Section of Proposed Third-Rail, Designed by Mr. W. B. Potter.

For the first third-rail installations, old track rails were used when obtainable, and these old rails were supplemented with new rails of standard T-section and composition. With the coming of the very heavy, high-speed service during the past few years, the resistance of these old and new standard T-rails was found to be so high that they would not carry the high currents necessary without too great a drop in the line potential. The rails would, therefore, have to be supplemented with additional copper feeders, but as this would be an expensive way to

*A paper read at the New York meeting of the American Institute of Mining Engineers, October, 1903.

†Chief of Testing Laboratory, General Electric Co., Schenectady, N. Y.

overcome the trouble, rails of higher specific electric conductivity were sought.

Because of the lack of specific data on the relation between conductivity and composition of mild steels, specifications for conductor-rails have usually been based on the fact that the conductivity of a metal is generally more or less directly in proportion to its purity. In most cases the purity of the iron specified for such rails has been so high that not only was it difficult to obtain, but the iron was also correspondingly of high price. One of the factors governing the choice between a third-rail and a trolley-wire is the relative price of steel and copper, allowance being made for the difference in conductivity. Hence, a balance must be struck between high conductivity (which is equivalent to saying a high degree of purity or freedom from the usual metalloids associated with iron) and the cost of producing the steel of the composition necessary for the conductivity required.

With the object of drafting a rational specification for such third-rail steels, a series of tests was started last spring, in the testing laboratory of the General Electric Co., on steels of as wide a range of composition as could be obtained from the steel makers, the results of these tests forming the basis of this paper.

When entering the market with an order for rails of special composition, difficulty was encountered in interesting railmakers, and the reason became apparent. The mills which make the standard T-rails, or standard rails of other sections (such as the girder and grooved rails), have generally been designed with the object of making such rails only, and practice throughout has been standardized to the greatest possible extent, both in the manipulation of the steel and in its manufacture in the furnace or converter. Hence, an order, even of considerable extent, for rails of special composition, has so upset the routine work that it was considered a nuisance to be endured, rather than a desirable business to be sought for. Obviously, then, recourse must be had to mills where such special compositions can be handled economically.

The T-section of rail was the outcome of designs intended to present the greatest life and strength of the section, with the least weight of the metal, conditions necessarily to be met in a running rail. But the conditions for the third or conductor-rail are different here, there must be provided sufficient surface for the collection of the current, and cross-section ample to carry the current without an undue drop in the line potential. The strength of the section is of little moment, and any section which is easily installed in an insulator is satisfactory. This permits the use of sections rectangular, or nearly so, which may be rolled easily in any mill equipped for the rolling of merchant-bar shapes of reasonably heavy weight, without any change in equipment or practice beyond the provision of grooved rolls of the necessary shape. Mills rolling merchant-bar or structural steel, today, are generally equipped to make steel in the open-hearth furnace, which readily lends itself to the making of steel of the special composition demanded by the electrical engineers for the third or conductor-rail.

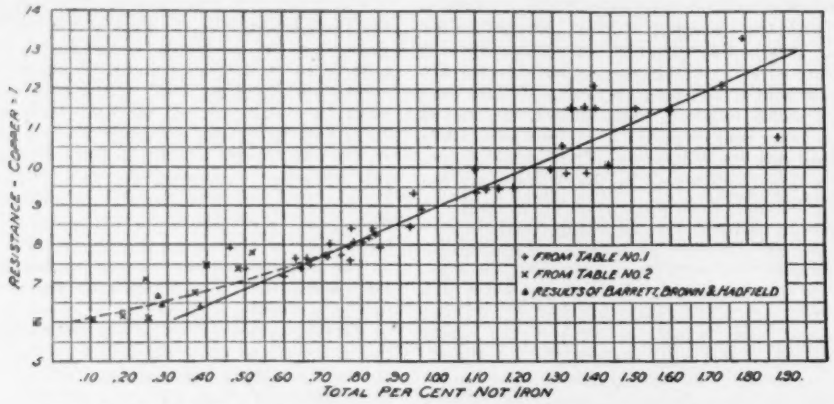


Fig. 1. Electric Resistance of Steel as Effected by Ingredients Not Iron.

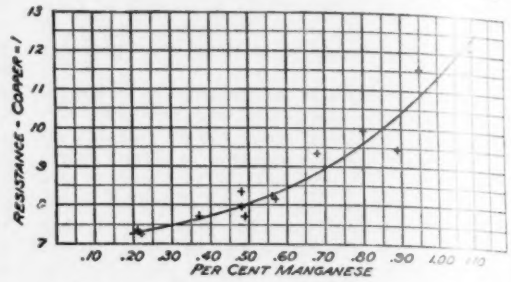


Fig. 2. Resistance of Steel, Variation With Manganese (Carbon 0.17 to 0.23%).

Having these facts in mind, a section (Fig. 6) of a conductor-rail has been designed by Mr. W. C. Potter, Chief Engineer of the Railway Department of the General Electric Co., which, when 2.5 ins. wide × 4 ins. high, will weigh about 98 lbs. to the yard. This shape may be easily rolled in any merchant-bar mill heavy enough to attempt sections of this weight. A dove-tail at the bottom provides an easy means of securing the rails by fish plates of special forms, and any of the common forms of bond may easily be applied. Ordered in lots of a thousand tons or more, such a rail should cost no more than a plain rectangle of equal weight.

To provide steels of sufficient range to give some indication of the relation between conductivity and composition, we obtained from as many of the steel makers as we could interest samples representing all of their common products. Some of the makers kindly provided us also with samples of special steels made in crucible charges. The samples were mainly forged or rolled bars of from 1 to 2.5 ins diam., and from them were turned bars of 0.75 ins. diam., or 1 in. diam. × 24 ins. in length, on which resistivity was determined. The chips from the finishing cuts were collected and these furnished the samples for analysis. Also, we cut similar bars from the heads of T-rails which were to be found in the yard tracks.

Table I. states the electrical resistance and the chemical composition of 45 samples of steel, and Table II. similar data on seven samples of wrought, or refined, iron, together with results on three samples of iron reported by Barrett, Brown and Hadfield in a paper referred to later in this article. The samples were numbered serially in the order of their resistance, No. 1 being of the highest resistance. Samples Nos. 1, 2, 4, 7, 11 and 12 are standard T-rails from several well-known makers, while Nos. 24 and 25 are cut from the 100-lb. T-rail used for the conductor on the Aurora, Elgin & Chicago Railroad. No. 45 is a T-rail used by the Underground Electric Railways Co., of London, and ordered from a steelmaker in Westphalia. Samples Nos. 46, 47 and 48 are ordinary refined bar-iron, while Nos. 49 and 50 are special brands of refined bar-iron sold for use in staybolts and similar work. Nos. 51 and 52 are Swedish and Norway irons, respectively.

The resistance is expressed in the three ways in which such results are frequently stated. The first column gives the specific resistance or resistivity of a section one square centimeter in cross-section and one centimeter long, expressed in microhms (ohms × 10^{-6}) and at the temperature given in the second column. In the third column is given the conductivity (on the basis of Matthiessen's determination of the resistivity of pure copper), i. e., the ratio of the resistivity of copper to that of the sample, expressed as a percentage. The fourth column gives the resistance of the samples compared with Matthiessen's copper as unity (the figures in the fourth column are the reciprocals of those in the third column multiplied by 100). The second half of the table gives the percentages of the usual elements to be found in steel or iron, the total percentage of these elements, and the sum of the percentages of phosphorus, sulphur and silicon.

The coefficient of change of resistance with change of

TABLE I.—Resistance and Composition of Steel.

Serial Number.	Specific Resistance. Microhms Per Cm³	Temp. °C.	Conductivity. Matthiessen Standard.	Resistance. Cu. = 1.	Percentage Composition. C.	Mn.	P.	S.	Si.	Total Red Fe.	P. + S. + Si.
1	22.72	19°	7.58	13.20	0.33	1.27	0.09	0.06	0.05	1.79	0.19
2	20.90	20°	8.27	12.12	0.17	1.09	0.09	0.05	0.004	1.404	0.144
3	21.29	25°	8.27	12.09	1.40	0.222	0.01	0.020	0.062	1.734	0.112
4	19.87	18°	8.65	11.55	0.20	0.95	0.10	0.08	0.05	1.38	0.23
5	19.80	19°	8.68	11.51	0.43	0.77	0.10	0.04	0.066	1.406	0.206
6	19.80	19°	8.69	11.51	0.36	0.80	0.10	0.04	0.047	1.347	0.187
7	19.81	20°	8.69	11.51	0.22	1.08	0.10	0.05	0.06	1.510	0.210
8	19.69	19°	8.73	11.44	0.74	0.58	0.043	0.036	0.20	1.599	0.279
9	18.95	25°	9.29	10.76	1.61	0.147	0.015	0.014	0.092	1.882	0.125
10	18.17	19°	9.46	10.56	0.41	0.72	0.039	0.041	0.11	1.32	0.190
11	17.27	19°	9.96	10.04	0.36	0.87	0.08	0.09	0.04	1.44	0.21
12	17.10	19°	10.06	9.94	0.37	0.73	0.09	0.04	0.06	1.29	0.19
13	17.10	19.5°	10.06	9.94	0.23	0.80	0.016	0.033	0.016	1.095	0.065
14	16.96	19°	10.14	9.86	0.30	0.95	0.063	0.01	0.01	1.333	0.083
15	16.95	19.5°	10.14	9.86	0.29	0.99	0.064	0.01	0.01	1.384	0.104
16	16.32	19°	10.56	9.48	0.23	0.89	0.058	0.01	0.005	1.193	0.073
17	16.25	19.5°	10.59	9.44	0.26	0.83	0.053	0.01	0.004	1.157	0.067
18	16.21	20°	10.62	9.42	0.28	0.65	0.084	0.06	0.05	1.123	0.193
19	16.09	19°	10.69	9.36	0.22	0.68	0.077	0.07	0.05	1.097	0.197
20	16.09	19°	10.69	9.36	0.16	0.66	0.074	0.030	0.014	0.938	0.118
21	15.32	19°	11.24	8.90	0.33	0.49	0.068	0.05	0.02	0.968	0.138
22	14.57	19.5°	11.82	8.46	0.31	0.45	0.10	0.04	0.026	0.926	0.166
23	14.49	20°	11.88	8.42	0.25	0.41	0.10	0.04	0.03	0.83	0.17
24	14.73	23.5°	11.88	8.42	0.144	0.45	0.09	0.08	tr.	0.774	0.17
25	14.62	23.5°	11.96	8.36	0.188	0.48	0.09	0.08	tr	0.83	0.17
26	14.15	19°	12.17	8.22	0.23	0.56	0.024	0.34	tr.	0.888	0.058
27	14.03	19°	12.26	8.16	0.192	0.57	0.024	0.34	tr.	0.82	0.058
28	13.86	19°	12.41	8.06	0.16	0.48	0.091	0.04	0.01	0.781	0.144
29	13.83	19.5°	12.44	8.04	0.10	0.55	0.08	0.05	0.024	0.804	0.154
30	13.80	19°	12.37	8.02	0.14	0.41	0.11	0.05	0.009	0.719	0.169
31	13.67	19°	12.58	7.95	0.23	0.48	0.024	0.01	0.023	0.767	0.057
32	13.54	19°	12.61	7.93	0.24	0.57	0.029	0.01	0.003	0.850	0.042
33	13.90	24°	12.63	7.92	0.10	0.25	0.04	0.02	0.05	0.46	0.11
34	13.31	19°	12.92	7.74	0.25	0.37	0.04	0.03	0.018	0.708	0.088
35	13.30	19.5°	12.94	7.73	0.23	0.49	0.024	tr.	0.004	0.748	0.028
36	13.27	19°	12.97	7.71	0.19	0.37	0.09	0.05	0.01	0.71	0.15
37	13.25	19°	12.99	7.70	0.27	0.41	0.024	0.01	0.001	0.715	0.035
38	13.18	19°	13.05	7.66	0.28	0.28	0.027	0.03	0.04	0.661	0.111
39	13.18	19°	13.05	7.66	0.07	0.40	0.08	0.07	0.013	0.633	0.163
40	13.07	19°	13.16	7.60	0.28	0.42	0.022	0.04	0.008	0.770	0.070
41	12.87	20°	13.37	7.48	0.16	0.36	0.08	0.04	0.009	0.669	0.129
42	12.73	20°	13.52	7.40	0.15	0.45	0.011	0.033	tr.	0.644	0.044
43	12.69	19°	13.55	7.38	0.19	0.21	0.025	0.04	0.034	0.499	0.099
44	12.53	19°	13.74	7.28	0.215	0.22	0.051	0.113	.....	0.599	0.164
45	11.91	19°	15.63	6.40	0.05	0.19	0.054	0.059	0.03	0.383	0.143

TABLE II.—Resistance and Composition of Iron.

Serial Number.	Specific Resistance. Microhms Per Cm³	Temp. °C.	Conductivity. Matthiessen Standard.	Resistance. Cu. = 1.	Percentage Composition. C.	Mn.	P.	S.	Si.	Total Red Fe.	P. + S. + Si.
46	13.90	25.5	12.78	7.82	0.15	0.068	0.13	0.02	0.15	0.518	0.30
47	13.82	26.	13.37	7.48	0.15	0.064	0.036	0.02	0.13	0.40	0.186
48	13.10	26.	13.50	7.41	0.16	0.074	0.12	0.027	0.10	0.481	0.247
49	12.54	25.5	14.07	7.11	0.08	nil.	0.13	0.00	0.024	0.242	0.162
50	11.92	25.5	14.80	6.78	0.17	0.027	0.074	0.022	0.077	0.370	0.173
51	10.82	24.	16.21	6.17	0.058	0.10	0.014	tr.	0.012	0.184	0.026
52	10.80	25.5	16.34	6.12	0.16	0.018	0.049	0.011	0.015	0.252	0.075
L88	11.40	17.	15.00	6.68	0.05	0.180	0.013	0.011	0.02	0.274	0.044
B	11 00	17.	15.57	6.44	0.020	0.036	0.063	0.018	0.14	0.287	0.227
SC1	10 35	17.	16.55	6.06	0.028	tr.	0.091	0.009	0.07	0.107	0.079

TABLE III.—Resistance of Steel. Variation with Manganese (Carbon from 0.17 to 0.23%).

Sample Number.	Manganese.	Resistance.	Carbon.	P. + S. + Si.
	Per Cent.		Per Cent.	Per Cent.
2	1.09	12.12	0.17	0.144
4	0.95	11.55	0.20	0.23
7	1.08	11.51	0.22	0.210
13	0.80	9.94	0.23	0.065
16	0.89	9.48	0.23	0.073
19	0.68	9.36	0.22	0.197
25	0.48	8.36	0.188	0.17
26	0.56	8.22	0.22	0.058
27	0.57	8.16	0.192	0.058
31	0.48	7.95	0.23	0.057
35	0.49	7.73	0.23	0.028
36	0.37	7.71	0.19	0.15
43	0.21	7.38	0.19	0.099
44	0.22	7.28	0.215	0.164

TABLE IV.—Resistance of Steel. Variation with Manganese (Carbon from 0.27 to 0.33%).

Sample Number.	Manganese.	Resistance.	Carbon.	P. + S. + Si.
	Per Cent.		Per Cent.	Per Cent.
1	1.27	13.20	0.33	0.19
14	0.95	9.86	0.30	0.083
15	0.99	9.86	0.29	0.104
18	0.65	9.42	0.28	0.193
21	0.49	8.90	0.33	0.138
22	0.45	8.46	0.31	0.166
37	0.41	7.70	0.27	0.035
38	0.28	7.66	0.28	0.111
40	0.42	7.60	0.28	0.070

TABLE V.—Resistance of Steel. Variation with Carbon. (Manganese from 0.15 to 0.30%.)

Sample Number.	Carbon.	Resistance.	Manganese.	P. + S. + Si.
	Per Cent.		Per Cent.	
3	1.40	12.09	0.222	0.112
9	1.61	10.76	0.147	0.125
33	0.10	7.92	0.25	0.11
38	0.28	7.66	0.28	0.111
43	0.19	7.38	0.21	0.099
44	0.215	7.28	0.22	0.164
45	0.05	6.40	0.19	0.143

TABLE VI.—Resistance of Steel. Variation with Carbon. (Manganese from 0.4 to 0.6%.)

Sample Number.	Carbon.	Resistance.	Manganese.	P. + S. + Si.
	Per Cent.		Per Cent.	Per Cent.
21	0.33	8.90	0.49	0.138
22	0.31	8.46	0.45	0.166
23	0.25	8.42	0.41	0.17
24	0.144	8.42	0.46	0.17
25	0.188	8.36	0.48	0.17
28	0.16	8.06	0.48	0.144
30	0.14	8.02	0.41	0.169
31	0.23	7.95	0.48	0.057
35	0.23	7.73	0.49	0.028
37	0.27	7.70	0.41	0.035
39	0.07	7.66	0.40	0.163
40	0.28	7.60	0.42	0.070
42	0.15	7.40	0.45	0.044

temperatures is practically the same for copper and for ordinary steel and iron, hence, even though resistivities are determined at different temperatures, the conductivities or comparative resistances derived therefrom are directly comparable within limits close enough for the purpose of this discussion, without actual determinations of the temperature coefficient in each case, and the reduction of results to a basis of common temperatures. Therefore, in all succeeding reference to results, the resistance will be expressed as in the fourth column, i. e., the ratio of resistivity of sample to that of Matthiessen's copper.

The resistance of steel, as of other alloys, might be expected to vary more or less directly with its purity. Therefore, in the curve shown in Fig. 1 are plotted resistances and total percentages of metalloids. The curve was first drawn from the data in Table I. and was approximately a straight line, but on adding the results obtained for refined iron from Table II., the lower part of the curve was found to bend up as shown by the broken line. This would indicate that the increase in resistance, due to increasing percentages of metalloids, becomes gradually greater up to about 0.75% of metalloids, after which it follows a straight line up to about 2% of metalloids; beyond this latter point our samples did not extend.

By the selection of samples of a composition varying in one element only, an attempt was made to define separately the influence of the several elements upon the resistance of steels. In Table III. are listed those samples having carbon between 0.17 and 0.23%, manganese being the principal variable; and in Table IV. are listed samples with manganese variable and carbon constant at from 0.27 to 0.33%. These results are plotted on the curves shown in Figs. 2 and 3, which show that the effect of manganese in increasing resistance gradually increases with the percentage of manganese present, within the limits represented by these samples.

Messrs. Barrett, Brown and Hadfield* in the study of the influence of manganese on resistance, used steels containing from 0.5 to 18.5% manganese, and found the resistance to increase at first very rapidly, with constantly increasing percentage of manganese, then more and more slowly, until 7% manganese, after which a further increase in the percentage of managese produces little or no increase in resistance. Le Chatelier† also gives figures showing the influence of manganese on resistance, but he has reported five samples only, and these are of such high carbon-content as to be of no service to us in the study of steels available for conductor-rails.

To determine the influence of carbon, we have selected, in Table V., those steels with manganese constant at from 0.15 to 0.30%, with carbon as the principal variable. In Table VII. we have stated results given by Le Chatelier in the paper previously mentioned, and in Table VIII. the results of Barrett, Brown and Hadfield taken from the paper previously quoted. All of these figures are plotted on the curve shown in Fig. 4, where the solid straight line represents closely the results of Le Chatelier, while the broken line follows more nearly the average of the combined figures from all three sources. With uniformly increasing carbon, the resistance at first rises very rapidly, but the rate of increase gradually drops until it reaches a straight line at about 0.2% C, which continues up to limits of the carbon listed. In all cases the steel is supposed to be unhardened, as it has been shown by Barus and by Le Chatelier that hardened steels may have double or even treble the resistance found in the annealed state. Table VI. selects samples, with manganese constant at from 0.4 to 0.5% and carbon variable; these results are plotted on the curve shown in Fig 5, but the range of the carbon percentages is too small to permit the drawing of any curve. The broken line is drawn parallel to the straight portion of the line in the curve shown in Fig. 5.

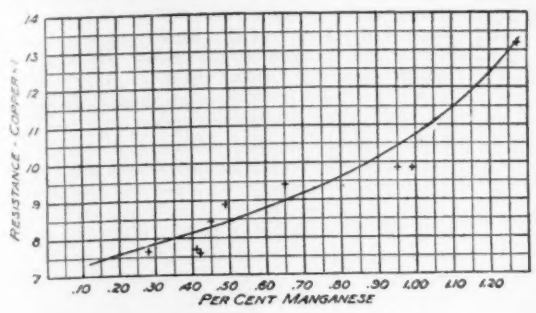


Fig. 3. Resistance of Steel, Variation With Manganese (Carbon 0.27 to 0.33%).

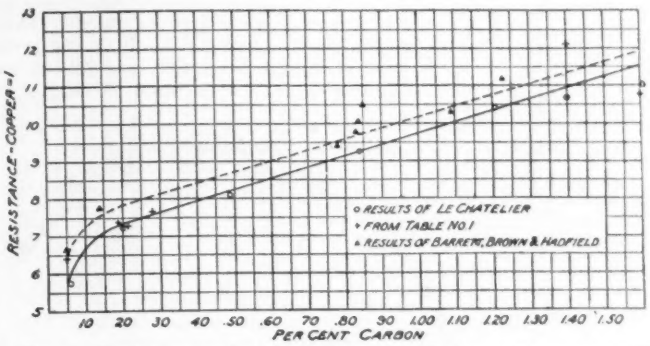


Fig. 4. Resistance of Steel, Variation With Carbon (Manganese 0.15 to 0.3%).

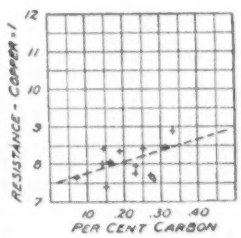


Fig. 5. Resistance of Steel, Variation With Carbon (Manganese 0.4 to 0.5%).

TABLE VII.—Resistance of Steel. Influence of Carbon. (Results of M. Le Chatelier.)

Resistance.		Composition.		
Microhms.	Cu. = 1.	C.	Mn.	Si.
		Per Cent.	Per Cent.	Per Cent.
10	5.78	0.06	0.13	0.05
12.5	7.22	0.20	0.15	0.08
14	8.10	0.49	0.24	0.05
16	9.25	0.84	0.24	0.13
18	10.40	1.21	0.21	0.11
18.4	10.64	1.40	0.14	0.09
19	11.00	1.61	0.13	0.08

TABLE VIII.—Resistance of Steel. Variation with Carbon. (Results of Barrett, Brown and Hadfield.) Temperature, 17° C.

Sample Mark.	Resistance.		Composition.		
	Microhms.	Cu. = 1.	Carbon.	Manganese.	Silicon.
			Per Cent.	Per Cent.	Per Cent.
1392G	19.1	11.19	1.23	0.14	0.12
1392L	17.6	10.31	1.09	0.32	0.17
1392A	17.9	10.49	0.85	0.32	0.17
1392B	17.2	10.07	0.84	0.18	0.20
1392I	16.7	9.78	0.83	0.25	0.06
1392H	16.1	9.43	0.78	0.10	0.10
1166A	13.4	7.85	0.14	.....	0.08

The elements phosphorus, sulphur and silicon were not present in sufficient quantity in any of the samples tested to permit us to draw any curves showing their influence upon the resistance. In both the papers previously quoted, the influence of silicon, when present in large quantity, is studied, but the number of samples tested is too small to warrant any conclusions that are really definite. In commercial steels the percentages of all three of these elements is so small that their effect on resistance may generally be neglected.

A study of the tables and curves given in the paper shows that manganese preponderates in influencing the resistance of steels, and that for lowest resistivity, this element must be present in very small quantity, much smaller than is usual in merchant or structural steels. While all the other elements must be present only in very small percentages, so great is the preponderance of the influence of manganese, that they may be tolerated in quantities, which the steelmakers would consider reasonable, without unduly increasing the resistance.

For a satisfactory third-rail, the lowest possible resistance (from 6 to 6.5 times that of copper?) is not necessary; and the great cost of making such extremely pure steel is not warranted. In fact, such extremely pure steels would probably be so soft that the frictional wear of the collecting shoe would be excessive and the life of the rail in service unduly short. Assuming, then, that a rail made from steel having a resistance not greater than eight times that of copper (13.8 microhms at 20° C) would be desirable for conductor-rails, the figures tabulated would seem to indicate that the following extreme composition would be permissible:

	Per cent.
Carbon up to	0.2
Manganese up to	0.4
Phosphorus up to	0.06
Sulphur up to	0.06
Silicon up to	0.05

This composition, however, would be extreme, and any overstepping of bounds might result in too great resistance; therefore, for resistance up to eight times that of copper, the specified analysis should be:

	Per cent.
Carbon not to exceed	0.15
Manganese not to exceed	0.30
Phosphorus not to exceed	0.06
Sulphur not to exceed	0.06
Silicon not to exceed	0.05

This latter composition is one which could be made easily in any open-hearth furnace and it should present no difficulty in rolling to a shape suitable for conductor-rails. In fact, steel of this composition has been successfully rolled into sheets as thin as 0.114 in., a size which was for a long time a standard product of a large sheet-mill.

* "On the Electrical Conductivity and Magnetic Permeability of Various Alloys of Iron," by W. F. Barrett, W. Brown and R. A. Hadfield, in "Transactions of the Royal Dublin Society," vol. vii., series 2, Part IV.

† "Sur la Resistance Electrique des Alliages," par M. H. Le Chatelier, in "Constribution a L'Etude des Alliages," published by the committee on alloys of the Societe d'Encouragement pour L'Industrie Nationale.

THE SOFT-GROUND TUNNEL UNDER THE REGENTS CANAL, WHITECHAPEL & BOW RY., LONDON.

In constructing the London underground railway connecting the Metropolitan District Ry. at Whitechapel with the London, Tilbury & Southend Ry. at Bow, it was necessary at one point to carry a twin tube tunnel under the Regent's Canal through soft ground and at a depth barely clearing the canal invert. This tunnel was about the only individual work of special interest on the line and from an extended description of the road being published in London "Engineering" we have compiled the following account of the tunnel construction.

Briefly described the tunnel is a cast-iron lined twin tube structure about 150 ft. long and passes transversely under the Regents Canal, where it is carried in conduit under Mile End Road. The canal conduit is a polycentric structure in masonry. The tunnel tubes are 18 ft. in diameter with a clear space between them of 2 ft. They are lined with cast-iron rings 2 ft. long, each ring being composed of 13 segments. Each tube carries a single railway track and the tube section is approached at each end by a double-track concrete and brick arch subway which widens out into a bell mouth as the end of the tube section is neared. The ends of these bell mouths are closed by brickwork bulkhead walls, through which the tubes are pierced. Fig. 1 is a section showing the end of a bell mouth and the closing bulkhead wall, and Fig. 2 is a transverse section through the tubes at the longitudinal axis of the canal conduit. The materials penetrated and the close approach of the tunnel to the invert of the canal are clearly indicated by Fig. 2.

In constructing the tunnel the canal conduit was first under-pinned by three transverse piers of concrete and brick masonry built clear of the tunnel section. Two trenches were then excavated across Mile End Road and in each of these was built one of the bulkhead walls, Fig. 1. These trenches were 10 ft. wide and 50 ft. deep. The bulkhead wall in each was built close against the trench side nearest the canal and was filled behind with grout pumped under pressure. As each wall was constructed there were built into it the first two rings of the tube tunnels. The earth faces inside these rings were close boarded and strutted. When the two bulkhead walls had been completed, excavation was begun back from them putting in a length of bell mouth sufficient to give working space for driving the tube section. A hole left in the roof of the bell mouth at each trench provided working shafts.

The method of excavating the tube tunnels is shown by Figs. 3 to 9, inclusive. The materials penetrated, as shown by Fig. 2, was wet gravel for the upper 6 ft. of the tunnel section and solid London clay for the remaining portion. Extreme care was required in handling the wet gravel to prevent its running. A timbering method of excavation was adopted, as the length of tunnel was too small to warrant the expense of a shield plant, and the English method of timbering was

followed in so far as to take out a length of tunnel to full section before erecting the lining.

The first step of the excavation was to open a rectangular top heading through the face sheeting, as shown by Fig. 3. This was timbered with frames consisting of side posts and cap lagged outside on both side walls and roof. The dimensions of this heading were 6 ft. × 4 ft. and the caps were placed high enough to allow a crown-bar to be inserted underneath them and clear the following crown segments of the lining. A length of heading having been excavated and timbered and its face lagged, the crown-bar was inserted underneath the caps with its rear end resting on top of the preceding section of cast-iron lining and its front end posted up from the bottom of the heading. Two side bars were then inserted and supported in a similar manner and distance pieces were wedged between the three bars. The timbering at this stage is indicated by Fig. 4.

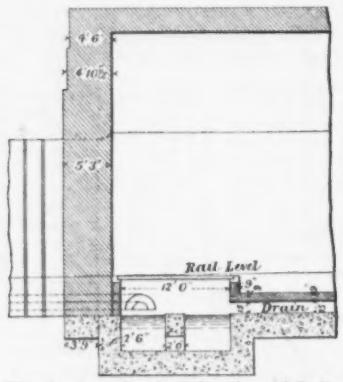


Fig. 1. Longitudinal Section of Bulkhead Connecting Bell Mouth and Double Tube Tunnel.

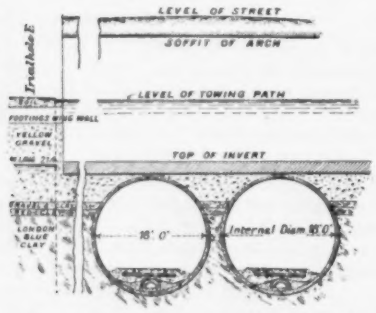
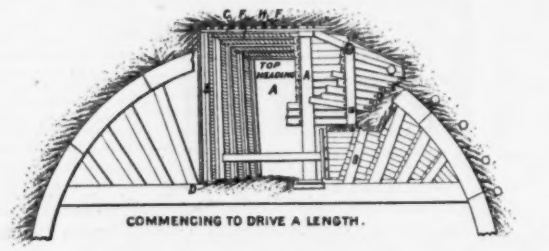


Fig. 2. Transverse Section of Twin Tube Tunnel Along Axis of Canal Conduit.

The second step of the work was to widen the top heading right and left. Considering the widening of one side only to prevent confusion, reference will be made to Fig. 3. The first operation was to cut out the side boarding down to the level of the third bar. Excavation was then begun sidewise, driving poling boards in advance to hold the roof and keeping all faces sheeted. As the excavation advanced one bar after another was inserted and posted up until the six on each side of the crown had been set. Figs. 3 and 5 indicate the progress of the timbering and its completed form. The next operation was to put in the top sill and insert posts between it and the roof bars, as shown by Fig. 6.

The third step of the work was to open a narrow drift under the top sill and extending down to the level of the second sill. This drift was sheeted on sides and face, as shown by Fig. 7. Props were inserted between the bottom of the drift and the top sill and then widening was begun right and left, keeping all faces boarded. As the widening advanced additional props were inserted until the widening had reached the full width of the section, when side bars and poling boards were inserted. The lower sill was then placed and posts inserted between it and the top sill. The excavation nearly ready for inserting the lower sill is shown by Fig. 8. A drift was then opened below the lower sill and widened in exactly the same way as just described, and these operations were repeated until the full section was opened. Fig. 9 shows the nearly completed timbering looking down one side from top to bottom and also shows the laps and supports.



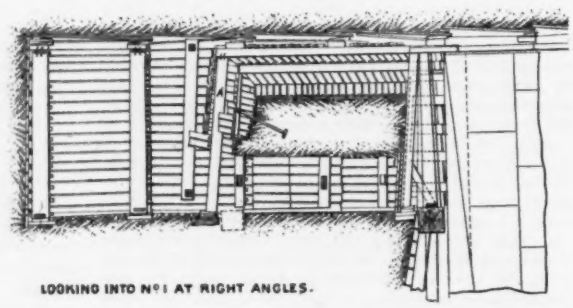


Fig. 3. Sketch Showing Method of Widening Top Heading.

The timbering was advanced in lengths varying from 4 ft. to 8 ft.; only a few lengths of 4 ft. were done, increases being made to 6 ft. and then to 8 ft., which was the length employed for 75% of the work. After completing each length of excavation and timbering the lining was erected within it, beginning at the bottom segment. Each ring of lining being 2 ft. long, two, three and four rings were erected at a time, depending on the length opened. After the lining was completely in place for each length it was grouted behind after all large voids had been filled with brickwork. Although the tunnel excavation bored the invert of the canal conduit no mishap occurred. The greatest of care was necessary, however, in taking out the wet gravel; all faces had to be boarded closely and the poling was packed with straw. This excessive care made the upper half of the tunnel section very expensive to open up. The time required for the construction was six months.

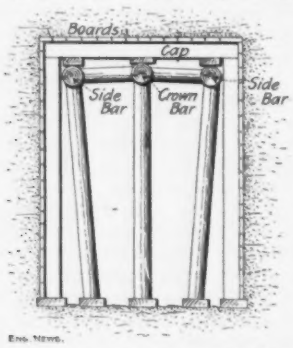


Fig. 4. Detail of Timbering Top Heading.

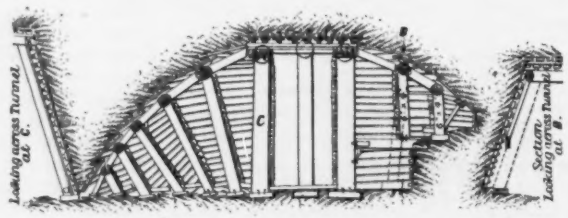


Fig. 5. Sketch Showing Widening of Top Heading Nearly Completed.

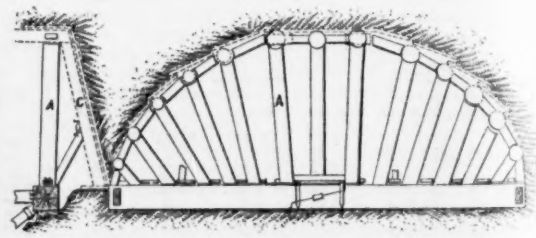


Fig. 6. Sketch Showing Top Heading Widened and Top Sill in Place.

ANNUAL CONVENTION OF THE AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.

The tenth annual convention of this Society was held at Indianapolis, Ind., Oct. 20 to 23, the headquarters being at the Hotel English, and the meeting being held in the assembly room of the Commercial Club.

In his presidential address, Mr. Chas. H. Rust, of Toronto, stated that the satisfactory increase in membership and also in attendance at the present meeting would have been even greater had it not been for other and similar organizations. A number of officials, in response to an invitation to attend this convention, had replied that they could not because they had arranged to go to the meeting of the League of American Municipalities, which came two weeks earlier. In connection with a review of the field of municipal engineering, Mr. Rust said of sewage disposal that the septic tank, followed by land treatment, seemed to him to be the most promising method for this country. Quieter pavements for business centers are in demand, and narrower paved roadways for residence streets are growing in favor. Municipal ownership was approved, since its adoption would abolish much of the prevalent municipal corruption due to franchise companies.

On the subject of the method of selecting city engineers, Mr. Rust said:

> A short time ago there was some discussion in the press upon the best method of appointing city engineers. In Canada the city council appoints the municipal officers during good behavior, which system has been found to work satisfactorily. This is also the universal custom in England, and it appears to me to be preferred to the suggestion that the engineer be elected by the citizens. I am of the opinion that an official cannot be a good engineer and in addition devote his time to politics. One of the difficulties and drawbacks to the more successful administration of public affairs in American cities is the frequent change of officers, caused by the almost universal introduction of politics into municipal government. This is a matter much to be deplored.

The report of the Secretary, Mr. G. W. Tillson, of Brooklyn, N. Y., showed receipts of $712 and expenditures of $707. It also called attention to the failure of members to reply to letters and communications from the Secretary, thus interfering with the work of the Society.

The report of the Committee on Municipal Data and Statistics was read by Mr. C. C. Brown, of Indianapolis. It was a progress report, outlining the discussion of the matter with the U. S. Department of Commerce and Labor and the American Society of Civil Engineers. The Department expects to begin to collect municipal statistics next year. The committee again submitted the proposed blank forms for such statistics which were submitted at the meeting last year.

A paper on "The Model City" was read by Mr. John N. McClintock, of Boston, dealing more especially with the relation of purity of water supply to the health and mortality records of cities.

It was suggested that written discussions of the papers presented might be sent in within two weeks of the close of the meeting, and this stirred up considerable discussion as to the method of procedure. Some members thought the printed Proceedings would be enlarged and made very expensive in this way, and suggested that the Secretary be empowered to alter, accept or reject the discussions. Others doubted whether there would be many written discussions, and thought they should be used without any censorship, being first submitted to the author of the paper to enable him to reply to any criticisms. The question of how

to deal with written discussions was eventually referred to a special committee, which reported that discussions should be received in duplicate by the Secretary within two weeks after the close of the convention, one copy to be sent to the author, but the Secretary to have power to accept or reject any discussion, as he might think advisable. This was adopted.

Mr. G. M. Ballard, of Newark, N. J., read a paper on "Municipal Taxation," in which he urged universal and uniform taxation, without the numerous exemptions which now exist. The result of such extensive exemptions is that in order to keep the tax within reasonable limits only enough money is raised for absolutely necessary requirements, but with universal taxation every real need would be met and the individual burden would be lessened.

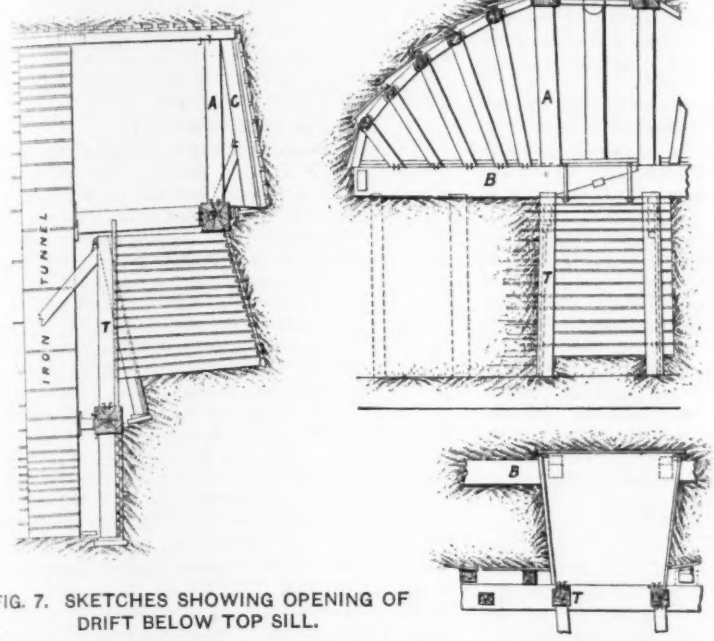


FIG. 7. SKETCHES SHOWING OPENING OF DRIFT BELOW TOP SILL.

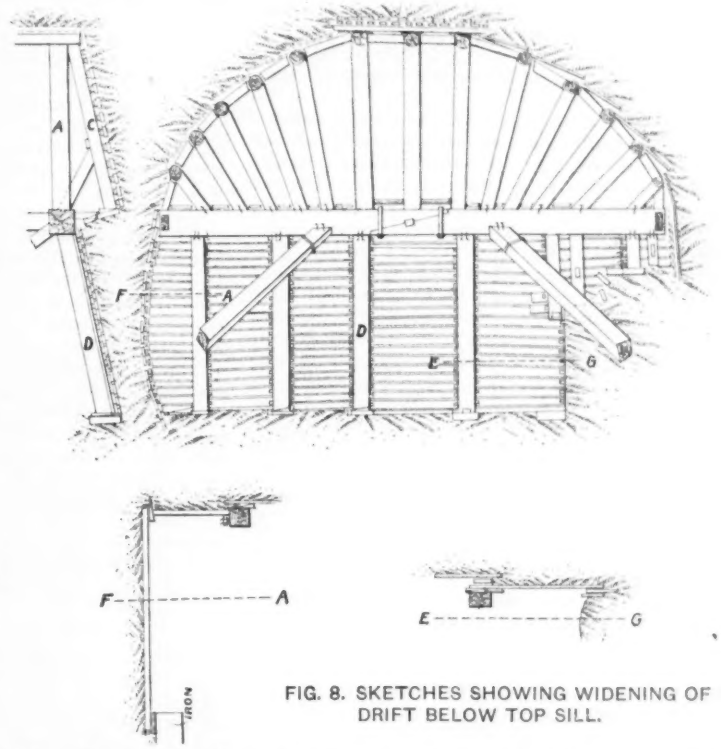


FIG. 8. SKETCHES SHOWING WIDENING OF DRIFT BELOW TOP SILL.

Prof. Severance Burrage, of Purdue University, then read a short paper on "The Sanitation of Public and Industrial Buildings." As to public buildings, he stated that in buildings erected with public funds (such as schools, asylums, city halls, etc.), much less attention is usually given to lighting, ventilation, plumbing, water supply, etc., than in public buildings erected with private funds (such as hotels, theatres, etc.). As to industrial buildings, manufacturers and employers have only within recent years realized that expenditures for good lighting, heating and sanitary equipment in factories is a profitable investment, as it results in better work and more work being done. He suggested that cities should have sanitary inspectors of buildings, in the same way as they now have plumbing inspectors and health officers.

GARBAGE DISPOSAL.

The report of the Committee on Garbage Disposal and Street Cleaning consisted mainly of a suggestion that instead of a technical paper on the subject, the committee should each year present information as to the progress made, the new systems installed, and the cost of the work. In the discussion it was remarked that many cities had no records or data of value as to cost, and Mr. G. H. Benzenberg (Milwaukee, Wis.), thought that if the committee would formulate a series of questions to be sent out for the purpose of its investigations, this would tend to produce the information desired, and also to effect some uniformity in the systems of records and estimates of cost.

A paper on "The Toronto Garbage Destructor" was then read by Mr. John Jones (Street Commissioner of Toronto, Canada). This destructor is about 35 × 10 ft., and 12 ft. high, and is of the three-story type. At the bottom is the ashpit, above this is the grate for the fires, and above this again is a row of firebrick bars forming a drying grate, upon which the garbage falls. In this way the checking of combustion by dumping wet garbage upon the fire is prevented. The destructor will consume about 60 tons of garbage per day. No night soil is handled, but the material collected averages 20% of kitchen waste and garbage. The street sweepings and factory refuse furnish nearly enough fuel, only about ½-ton of coal per day being required. The plant cost $5,000, was built by day labor, and is operated by six men. Temperatures of 1,800 to 2,000° F. are attained, and arrangements might easily be made to utilize this heat for making steam. Mr. Jones thought that water bars would last longer than the fireclay bars. The cost of collection is 55 cts. per cu. yd., and that of burning is 20 cts. per cu. yd.

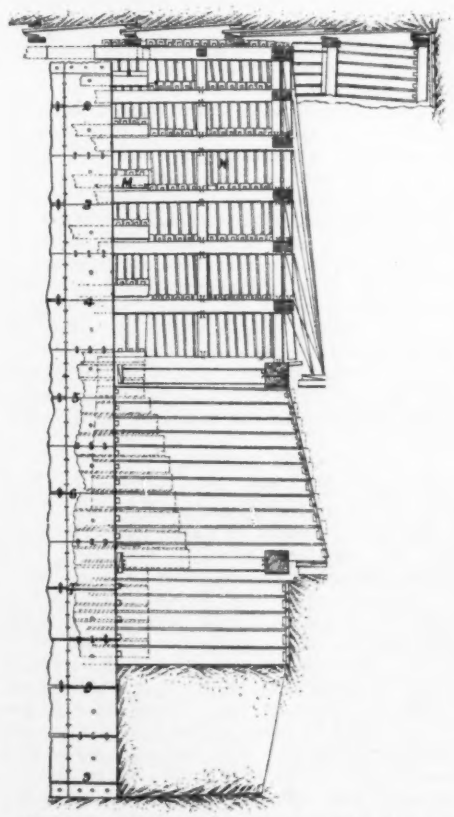


Fig. 9. Vertical Section Showing Side View of Timbering Nearly Completed.

Mr. Geo. H. Benzenberg (Milwaukee, Wis.) said that in many cities the street sweepings and factory refuse are disposed of by other departments than that having to do with the garbage, and such cities would be likely to use a reduction process. He described one such process in which the garbage is reduced in steel tanks having steam jackets and interior steam drums, but boiling is prevented by maintaining an air pressure some 15 lbs. higher than that of the steam pressure. In this way the material becomes disintegrated. It is then run into a dryer. The residue has a considerable commercial value, 13% (3%?—Ed.) being oil and grease, besides which there is ammonia and phosphate. Mr. Jones said that the Toronto destructor did not get garbage from hotels and restaurants, which is carted away by country people, and therefore reduction would not pay. Mr. Benzenberg, however, said that the same conditions existed at the plant he referred to, and it was found that it did pay to use the reduction process.

PERVIOUSNESS OF SEWERS.

A paper on this subject was read by Prof. A. Prescott Folwell, of Easton, Pa., who commenced with a quotation from an editorial in Engineering News, and with a reference to the letter from Mr. Hazlehurst in our issue of Aug. 27. He referred mainly to the separate system of sewers, and mentioned that at Plainfield, N. J., the sewage beds had at one time been rendered practically useless by the large inflow of water. The results from various cities were given, showing an infiltration of 30,000 to 80,000 gallons per mile per day. Carelessness and the difficulty of making tight cement joints in wet trenches are among the principal causes of infiltration. Cast-iron pipe with lead joints will make water-tight work, and though it is an expensive plan it may pay to use it in wet ground. Creosoted wooden pipe is almost absolutely tight. At Washington, D. C., concrete has been put under the pipe and over the joints. For brick sewers, he suggested building the outer ring first, to the level of the springing line, leaving holes to admit the surface water until the mortar has set. Then the holes would be plugged, the inner surface coated with a ½-in. layer of rich cement, and the inner ring of brick laid upon this. He has used this plan also with concrete, setting pipes in the outer ring, which were plugged after the concrete had set. Ordinary concrete is reasonably impervious, if built with good materials and good workmanship.

Mr. Reimer (South Orange, N. J.) said he had built a pipe sewer in marshy land where the ground water stood on the surface and where part of the work was in quicksand. The work was done by day labor, and the foreman was instructed to see that water was kept from the joints until the cement had set. This sewer proved to be almost perfectly dry. Another member referred to the use of coal tar and cement for making the joints, and mentioned a case where four lengths of pipe were put together on the surface, and the 12-ft. section lowered into the trench. This was to reduce the number of joints made in the trench.

Mr. T. C. Hatton (Wilmington, Del.) thought that a sewerage system ought to lower the ground water level, and doubted the advisability of making Mr. Reimer's sewer water-tight. Mr. Reimer, however, explained the local conditions which made it necessary. A combined system would have cost $5,000,000, which would have been prohibitive, but the separate system cost only $800,000. A storm water system will be built later and no attempt will be made to make this water-tight. Mr Tillson (Brooklyn, N. Y.) said that in Col. Waring's work at Memphis special care was taken to make the separate sewers water-tight, in order to prevent sewage from leaking out. He himself had made water-tight sewers at Kalamazoo, Mich., employing a man to pack with care all joints with gasket and then with Louisville cement. It must be remembered that in some cases the ground water level varies so that if the sewer is not tight, water may leak into it at one time while sewage leaks out of it at another time. He did not think it was the purpose of a separate sewer to take care of ground water. Another member remarked that Orange, N. J., built a separate system of sanitary sewers and storm water sewers at the same time, the extra cost being only that due to the pipe and pipe laying.

ENGINEERING FEATURES OF INDIANAPOLIS.

The evening session was devoted to a series of interesting papers on the municipal engineering features of the city.

STREET PAVING.—The first paper, on "The Paving System of the City," by Mr. James B. Nelson, City Engineer, was read by Mr. Buehler, Assistant City Engineer, in the absence of the author. The modern paving system originated in 1888, when a street was paved with tar-macadam (termed vulcanite), laid in three layers, while in 1889 the first ordinance for sheet asphalt was passed. The present cost of asphalt paving, with a 9-year guarantee, is $2.10 per sq. yd., exclusive of grading. Besides a large amount of sheet asphalt of various kinds, the city has some brick paving, wood block (treated and untreated), macadam, and gravel streets. It is said that the wood block paving is more slippery than asphalt when it becomes wet in cold weather. In one place sand was thrown on the pavement, which was ground into the wood by the traffic and tended to roughen the surface. The city has an area of 29.3 sq. miles, with 445 miles of streets. As to the maintenance of asphalt pavements, Mr. Nelson made the following statement:

> Taking as a basis the average character of the asphalt pavements, it is my opinion that for maintaining them after the expiration of the 9-year guarantee, the most economical plan in the end should provide for an average repair fund of about 10 cts. per sq. yd. per annum. By so doing, and by making the repairs judiciously and at the proper time, it will be practicable to maintain them for a further average period of 6 or 7 years. This is approximately 5% of the original cost per annum.

Following this, Mr. Reilly read a short paper on "The Creodone Wooden Block Pavement," as used in Indianapolis. The blocks are rectangular, and laid in courses diagonally across the street.

THE PARK SYSTEM.—This paper was read by Mr. George Merritt, Park Commissioner, and was illustrated by a number of stereopticon views of the parks, boulevards, public playgrounds for children, etc. As to the political uses of parks we quote the following:

> From 1873 to 1894, Garfield Park was little more than a political football, used alternately by each political party to pay its campaign debts; one party hauling in dirt to fill in the low ground, and the other digging it out again to make a lake, thus doing and undoing because there was no head or system. This continued until 1895, when the non-partisan Board of Park Commissioners created by the legislature took charge of Garfield Park and began a system of improvement that has gone steadily forward ever since that time, giving the city a beautiful park.

THE WATER-SUPPLY SYSTEM.—This paper was by Mr. F. A. W. Davis, General Manager of the Indianapolis Water Co. He described the present system, supplied from 30 wells averaging 320 ft. in depth, and pumped by the air-lift system. He then described the new works, water for which will be taken from the White River, above the city, brought eleven miles through the company's canal (which will serve as a settling basin) and then passed through sand filters, the bottom of the filter bed being formed by clay tile like electric conduits, but having their tops perforated with small holes. A concrete-steel conduit will carry the filtered water to a clear water reservoir at the pumping station, where new pumps are being erected.

OTHER LOCAL FEATURES.—A paper on "The Sewer System of Indianapolis" was read by Mr. C. C. Brown, former City Engineer, in which he referred to the Northwestern Ave. sewer recently described in our columns. Mr. W. K. Eldridge followed with a paper on "The Central Heating Plants," the city having a steam-heating and a hot-water heating system, both operated by companies. The series of papers was concluded with one on "The Street Railway System and Interurban Lines," by Mr. Thomas B. McMath, Engineer of the Indianapolis Traction & Terminal Co. The reconstruction of tracks has cost the company $300,000 per year for the past four years. One particular feature of interest is the new terminal station now being built to accommodate the cars of the interurban lines, of which six are now in operation, with several others under construction.

ELECTRIC LIGHTING.

At the morning session on Oct. 22, a brief report of the Committee on Electric Street Lighting was presented by Mr. E. A. Fisher (Rochester, N. Y.). He stated that there has been a decrease in the charge for arc lighting. He also suggested the adoption of some such system of regulating rates as is in use at Boston, where the price is subject to periodical revision by arbitration. Mr. Fisher presented a paper giving the statistics of electric lighting at Rochester. A paper by Mr. H. W. Hillman, of the General Electric Co., described some of the recent improvements in the artistic design of lamps and posts for electric lighting.

The next paper was on "The Records of the City Electrician," by Mr. A. S. Hatch, of the Detroit Lighting Commission. This covered the same ground as a paper read by him at the meeting of the International Association of Municipal Electricians, at Atlantic City, N. J., in September. For records, he uses cards 6 × 9 ins., with a city block to each card, on a scale of 100 ft. to 1 in. The lines, poles, manholes, etc., are all shown, poles numbered, and different colors indicate the ownership. The sizes of manholes, and depths to water and gas mains and sewers are shown, with the number of ducts and ownership of cables. Other cards show the size, height and wood of poles, the number of cross arms and wires, etc. Tabulated card records give descriptions of poles, arms, wires, ducts, lamps, etc., with rentals and other information. There is a card index key to all this, and one man can take care of the entire system.

CITY PARKS.

The report of the Committee on Park Development and Maintenance was read by Mr. G. A. Parker, Superintendent of Keney Park, Hartford, Conn. He considered parks as something more than ornamental accessories, and as being necessary to municipal welfare. The cities represented in the Society have 536 parks, aggregating 41,500 acres, and costing $5,000,000 per year for maintenance. Parks should be connected by parkways to form a comprehensive system. Public playgrounds are very important. There are over 400 parks operated by street railways, and these are often better patronized than the public parks. One reason is that the working people, living monotonous lives, desire the variety and activity of the entertainments provided. Mr. Parker suggested that similar attractions should be provided in city parks. He pointed out that in too many cases park rules are devised for the protection of the trees, flowers and grass rather than for the interests of the people, for whom the parks are primarily established. Referring to the improvement of the city of Washington, Mr. Parker mentioned the fact that the report of an expert commission appointed to make recommendations, had been rejected by Congress, without regard to the merit of the report, because the committee had spent $48,000 in its investigations. On his motion a resolution was passed endorsing the plans of the McMillan commission, or similar plans in harmony with the original designs of General L'Enfant and President Washington.

Mr. Morris R. Sherrerd, Newark, N. J., then read a paper on the water supply system of Newark, and particularly of the 60-in. concrete-steel conduts. These are of 10-in. concrete, with expanded metal embedded within it.

STREET PAVING.

The afternoon session was devoted to papers on this subject. Mr. N. P. Lewis (New York) referred to the enormous amount of work being done in repaving in all large cities, and also to the comprehensive work at Harrisburg, Pa., where paving, sewers, garbage collection and water supply are all being improved. He remarked that in New York city the policy is to refuse all petitions for macadam paving, for while it is low in first cost, its cost of maintenance is high. Mr. Ernest Adam (Newark, N. J.) presented a detailed paper on the pavements of Newark, their development and their cost. Cobblestones were used almost exclusively until 1872. A paper on "Cobblestone Pavements" was read by Mr. G. W. Tillson, showing that Brooklyn, N. Y., had 320 miles of cobblestone in 1880, had practically no other paving until 1888, and now has 175 miles. The old stones are broken up for concrete.

A paper on "Maintenance of Asphalt Pavements in Rochester, N. Y.," by Mr. W. T. Stewart (Assistant City Engineer of Rochester), was then read. There are 46 miles of asphalt of various kinds, including 8 to 10 miles of rock asphalt. Since 1897 a 10-year guarantee has been required, and in 1901 the council decided to require this guarantee for all kinds of pavements. The average cost per sq. yd. for repairs was 4.21 cts. in 1897, 2.10 cts. in 1898, 3.17 cts. in 1901, and 4.72 cts. in 1902. The cost of the pavements was from $2.50 in 1885 to $2.96 in 1898, but in 1902 the price was $1.74, owing to competition with brick. In the discussion, Mr. Tillson said that the cost of repairs of asphalt pavement in Brooklyn, N. Y., in 1902, was as follows: Streets without car tracks, 4.18 cts.; streets with car tracks, $17.8 cts.; average, 5.79 cts. Under the old system the average was 16 cts.

Mr. Giddings, City Engineer of Atchison, Kan., read a paper on "Single Course Brick Pavement," as used at Atchison. This is made with Atchison shale brick, and in 1902 cost 79 cts. per sq. yd. on sand, or $1.40 on concrete. Brick laid on macadam in 1895 cost 94.8 cts., including the subgrading and rolling the subgrade. Mr. C. D. Pollock, Brooklyn, N. Y., followed with a paper on "Medina Sandstone Pavements in Brooklyn." At first the blocks were laid with open joints filled with gravel, but they are now laid with tight joints, filled with cement grout. The blocks are 3½ to 5½ ins. wide, 6 to 8 ins. deep, and 7 to 12 ins. long, laid with a lap of 3 ins. It makes a good paving for residence streets where the grade is too steep for asphalt, and granite is too noisy. It costs $2.80 per sq. yd., exclusive of foundation, and 44,000 sq. yds. are now laid or under contract.

A paper on "Rectangular Wooden Block Pavements in New York," by Mr. F. A. Kummer, General Manager of the U. S. Wood Preserving Co. (New York), was read by Mr. N. P. Lewis. The blocks are of long-leaf yellow pine, 3 × 4 × 8 ins., treated by the creo-resinate process, and laid on a 1 to 1 sand and cement mortar, on a 4½-in. concrete foundation. The joints are filled with sand, and for steep grades the joints are grooved to a depth of 1¼ ins., to retain the sand and give a hold to horses' shoes. On the Williamsburg (East River) bridge, the roadways are paved with these blocks, laid directly upon the steel deck or floor. The series of papers was concluded with a paper

on "The Warren Bitulithic Pavement," by Mr. C. A. Kenyon, of Indianapolis. The area of this pavement laid annually increased from 14,400 sq. yds. in 1901, to 440,831 in 1902, and 858,999 contracted for up to July 15, 1903. On the subject of foundations for this class of pavement, Mr. Kenyon advised preparing a firm earth base by grading and thorough rolling. In case the natural material is so sandy that it will not pack, it may be flushed with water, after grading, and then covered with a 1-in. layer of marsh or other tough hay or straw. Upon the subgrade prepared in either manner 1 to 3-in. broken stone, free from dust and screenings, is spread. If the cost can be stood, the larger stones may be placed at the bottom and rolled, and the 1-in. stones used to bring the foundation to grade. Whatever the method, the foundation layer is sprinkled lightly with a thin bituminous fluid, and then the heavier cementing material, at a temperature of 200 to 260° F., should be applied. Opinions differ as to the advisability of rolling this foundation. Some contractors prefer rolling, to diminish the amount of cementing material. Mr. Kenyon stated as his own opinion he saw "little use or harm" in this rolling, provided the earth foundation had been thoroughly rolled. He also believed that a bituminous foundation was superior to one of ordinary concrete, because: (1) It is more compact and better able to withstand heavy loads, since it has been heavily rolled, whereas ordinary concrete receives only a light tamping. (2) The bituminous foundation is more elastic than concrete, and unites better with the wearing surface. (3) The bituminous foundation does not fill with water from below by capillary action, as does ordinary concrete. There was very little discussion of any of the papers on paving, but Mr. Reimer (South Orange, N. J.) suggested the advantages of wide tires for heavy wagons, in reducing the wear on the paving.

OFFICERS AND PLACE OF MEETING.

The election of officers resulted as follows: President, G. M. Ballard, Newark, N. J.; First Vice-President, A. P. Folwell, Easton, Pa.; Second Vice-President, C. C. Brown, Indianapolis, Ind.; Third Vice-President, W. B. Howe, Concord, N. H.; Treasurer, F. J. O'Brien, Oswego, N. Y.; Secretary, Geo. W. Tillson, Brooklyn, N. Y. The next meeting will be held at St. Louis, Mo., in 1904, and an endeavor will be made to hold a joint meeting with the League of American Municipalities.

A NEW USE FOR CALCIUM CARBIDE is given in Consular Report No. 1774. It is used for raising and sinking a submarine boat in Germany. The boat is supplied with an ordinary gas generator and a water tank, the upper part of which is connected with the gas reservoir of the generator. The tank and the generator have pipes at the bottom opening into the sea water. The upper parts have vertical pipes for the escape of the gas.

If the reservoirs (the tank and the reservoir of the generator) are filled with water, the boat sinks. After the introduction of a carbide cartridge into the gas generator an immense quantity of gas is formed at once, which forces the water through the lower pipe into the sea. After opening the cock in the connecting pipe, the gas enters the tank and fills it by forcing out the water. The boat now rises to the surface, remaining there until the gas is allowed to escape from both reservoirs, which causes them to be again filled by sea water. If the boat has sunk deeper than desired, the introduction of a sufficiently large carbide cartridge into the generator will make the boat rise to the proper level. The apparatus is quite simple and works reliably, doing away with air and water pumps.

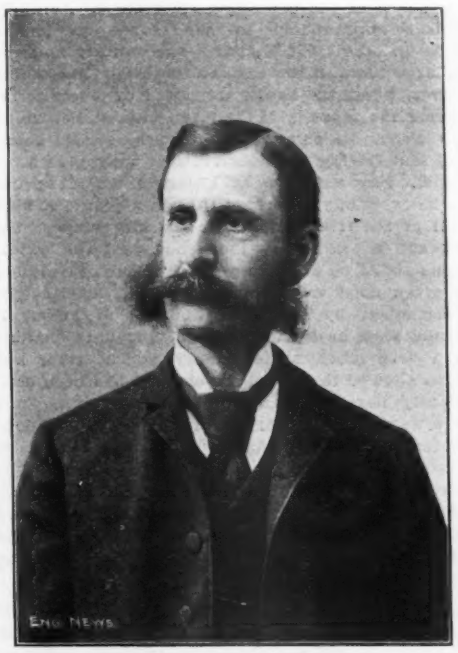
FIRE TESTS OF LUXFER PRISM GLASS have been recently made by Prof. Charles L. Norton at the Insurance Engineering Experiment Station, Boston, Mass. The report (No. XI.) gives details of the tests illustrated with half-tone cuts. Summarizing the results the report says:

The two tests resulted in demonstrating the ability of all the samples tested to remain in position and effective operation, up to the time when the temperature of the melting glass was reached. The Luxfer plates and prisms in 24 × 30 ins. stood the test quite as well as the 24 × 30-in. wired glass, and they were stronger at the close. The Luxfer plates 50 × 50 ins. were down nearer the fire, and the glass was undoubtedly hotter than the wired glass. But the wired glass was just at the melting point, as shown by the rounded edges of the cracks and the distortion of the plate. The results of the two tests indicate, that, as shown by these samples, the three materials, wired glass, electro-glazed prisms, and electro-glazed plates, when used in sheets 24 × 30 ins., are of practically the same effectiveness in resisting the action of fire. The condition of the 50 × 50-in. plates, during and after the test, shows them to be as effective as the 24 × 30-in. wired glass sheets, provided the melting point of the glass is not exceeded; and it is certain that, at this temperature, all of the samples tested would completely fail.

CHARLES EZRA GREENE.

Charles Ezra Greene, Professor of Civil Engineering and Dean of the Department of Engineering of the University of Michigan, died at his home in Ann Arbor, Mich., on Oct. 16. He had been ill for two years past, but his recovery was expected, and the end came suddenly. His death resulted from paralysis of the heart.

Prof. Greene was born in Cambridge, Mass., Feb. 12, 1842. After a preparatory course at the Cambridge High School and at Phillips Exeter Academy, he entered Harvard College in 1858, and was graduated from that institution as a Bachelor of Arts in 1862. His first work was in connection with an establishment for manufacturing breech-loading rifles; but in the early part of 1864 he enlisted for service in the Union Army, first doing duty as Quartermaster's Clerk in the rendezvous camp at Readville, Mass. In January, 1865, he was commissioned at First Lieutenant in the 7th Regiment of U. S. colored troops then serving before Richmond, Va.; he became regimental quar-



Yours very truly,
Chas E Greene.

termaster, and with his regiment he was transferred later to Indianola, Texas, where he resigned his commission in August, 1866.

Upon leaving the army Mr. Greene determined to adopt the profession of civil engineering, and with this end in view he entered the Massachusetts Institute of Technology, and graduated from that school in 1868. He was immediately appointed Assistant Engineer on the Bangor & Piscataquis R. R., in Maine, and on completion of that work he was employed by Gen. George Thom on U. S. River and Harbor Improvements in Maine and New Hampshire. He left this service to become City Engineer of Bangor, and in 1872 he was called to the chair of Civil Engineering in the University of Michigan, having previously declined a similar position in Washington University, at St. Louis. Prof. Greene had now entered upon his life work, and at the time of his death he had completed thirty-one years of continuous duty as Professor of Civil Engineering in that institution. He was the first Dean of its Department of Engineering, and had held that office for eight years.

Prof. Greene succeeded at the University of Michigan the late Prof. De Volson Wood, who had been at the head of this school of civil engineering for fifteen years, and had brought it to a high degree of efficiency. In 1872 Prof. Greene was still a young man and without experience in teaching; and this call to succeed a veteran and very popular officer was a severe test of his abilities. But no one could have more successfully sustained the trial. To start with, Prof. Greene had the advantages of a liberal education, backed by considerable experience in actual practice of the profession of civil engineering, but, in addition to these essentials, he possessed certain traits of character which are absolutely necessary for the making of an instructor of the highest order. He was naturally endowed with clearness of apprehension, a clean-cut style of expression, a quiet, self-possessed manner gave him control over others, and he was enthusiastic in all that related to his work, and took a hearty personal interest in the progress and welfare of his pupils.

The best indication of his success as an instructor lies in the fact that his department moved on as steadily as if there had been no change in its head, and it at once began to expand. Prof. Greene is credited by the officers of the University with having brought about the organization of the co-ordinate branches of mining and mechanical engineering as parts of the University course. The department of Mining Engineering was established in 1874 under Prof. Pettee. The department of Mechanical Engineering, including Marine Engineering, was an outgrowth of the Act of Congress of 1878, authorizing the Secretary of the Navy to detail engineer officers of the U. S. Navy as instructors in universities and scientific schools. In 1880, Prof. Greene strongly advised the then acting President of the University to take advantage of this provision of the law, and the fortunate result was the appointment of Prof. Mortimer E. Cooley to the new chair of Mechanical Engineering at the University of Michigan. It is thus chiefly through the influence and energy of Prof. Greene that the University now possesses a Department of Engineering, consisting of three well-established and well-equipped and flourishing branches.

Aside from his labors in the University, Prof. Greene did efficient work outside of that institution, both as an engineer and as a contributor to scientific literature. In 1880, he was Chief Engineer of the Toledo, Ann Arbor & Northern R. R.; in 1882 he was Superintendent and then Consulting Engineer for the erection of the Maumee bridge of the Wheeling & Lake R. R., at Toledo, O., and he was also Consulting Engineer for the Cherry Street bridge, in Toledo. He furnished the engineering plans and superintended the construction of the water-works at Ann Arbor in 1885, and planned the water-works for Pontiac and Ypsilanti in 1886.

In scientific investigation, Prof. Greene was especially active, and he early gave much attention to the development of graphical methods of analyzing the stresses in framed structures. Among his many contributions to engineering literature may be mentioned the following: "A Brief Treatise on the Analysis of Bridge Trusses," 1875; "Papers on Roof Trusses," published in Engineering News in 1875-76; and "Graphics for Engineers," which appeared in three parts in 1876-79. This latter and more important publication was divided under the three main heads of Roof Trusses, Bridge Trusses and Arches; and the second and third parts were largely devoted to setting forth a method of graphical analysis original with the author, which was well received by the engineering profession. His latest treatise, "Structural Mechanics," was published in 1897.

It is pertinent to mention here that Prof. Greene was, in 1876-77, the first paid contributor of Engineering News, and he wrote the majority of its editorials during those years.

Prof. Greene was the President of the Michigan Association of Engineers and Surveyors for three years after its organization in 1880, and on Jan. 4, 1882, he was elected a Member of the American Society of Civil Engineers. He received the degrees of A. B. and A. M. from Harvard University; the degree of B. S. from the Massachusetts Institute of Technology, and that of C. E. from the University of Michigan in 1884.

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

The account of the damage to bridges at Paterson, N. J., by the flood following the recent remarkable rainfall, as given elsewhere in this issue, deals with matters of much interest to engineers. The Passaic drainage area is relatively steep and contains no flood-retaining works, if we except some water-supply reservoirs on the upper Pequannock, one of the affluents of the Passaic. Floods of relatively large volume occur frequently, and may be expected in any season of the year. For example, six important floods have occurred in the Passaic Valley in the past 21 years; of these three were spring floods, while the others occurred respectively in September, October and December. The maximum volume of the flood produced by given rainfall and runoff conditions may, of course, be reduced by suitable storage works in the headwaters, placed where they will prolong the flood-wave and decrease its height. A proposal for such works has, indeed, been advanced for the Passaic Valley, but the realization of this plan does not appear to lie in the immediate future. For the present, therefore, works constructed in the Passaic River channel must be designed with due regard to high floods. Bridges crossing the stream should either be placed high enough to be above the maximum flood-level, or they must be designed for submergence in a rapid drift-carrying current. The latter expedient was adopted for the bridges of which we show photographic views on another page. The result shows that they did not uniformly stand the severe test to which they were put by the latest flood. It may be objected that the bridges themselves were amply strong, but had weak foundations. However, beside the fact that it has not yet been shown definitely that the foundations alone were at fault, in the case of the Paterson bridges, it must be remembered that the foundations are as much an essential part of a bridge as is the superstructure. The fact remains that out of four "submerged" bridges two were wholly or partially destroyed. This is worth noting for the reason that, if we remember correctly, the expedient of placing bridges below flood-level has been adopted in a number of cases in recent years, where conditions made a high-level bridge impracticable. A bridge of this kind may in flood-time experience pressures and impacts large in amount and very difficult to estimate. Moreover, in nearly all cases the great channel obstruction which such bridges form when submerged must give rise to greatly intensified scouring action between and around the piers. Unless the latter rest on the very soundest foundation, their resisting power in strong floods must always be a matter of doubt.

The reduction of flood-heights is not solely dependent upon storage works, of course. For a given maximum flow past any section of a stream, all that is needed (in the abstract) to prevent floods is to provide a channel capable of passing that flow at the prevailing river slope. Actually, this is impracticable in many cases and impossible in others. It has been successfully done on a large scale in the case of the lower Mississippi River, where the banks are raised by levees to increase the capacity of the river without disturbing its slope. In some cases deepening the channel and freeing it of obstructions may give some relief. The situation at Paterson would appear to be especially favorable to such a plan: A high fall in the river just above the city renders the stream below largely independent of the conditions above, so that the problem is one of handling a given flood volume rather than a flood-height determined by the river above. However, it would seem as if the matter of adequate channel had been much neglected here. The river has been allowed to silt up, the channel has been constantly narrowed, and bridges have been built in a way to still further obstruct the flow of floodwaters. It is not going too far to say that these obstructions to the channel have raised the high-water level of large floods at Paterson several feet above the point which they would reach were the river bed in its natural condition. That the upper few feet of a flood usually do most of the damage goes without saying.

It is a remarkable fact that of the bridges at Paterson which we illustrate, the two wrecked structures were of concrete, while the other two are steel structures. Nevertheless, this fact should not be taken as an argument against concrete bridges as compared with steel without considering all the circumstances involved. The fall of one-third of the width of the West St. bridge over two spans, without injuring the remaining portions of the ribs, may even be taken to speak in favor of the concrete bridge, since in case of a steel bridge the failure of part of a span would inevitably wreck the entire span. Rather more clearly, however, we may see in the behavior of these four bridges an argument against the excessive use of arched spans, especially masonry or concrete arches, for bridges with piers that may be endangered by erosion. The smallest movement of the piers results in cracking or total collapse of the arch span which it carries. In the case of bridges of several spans, the fall of one span is almost necessarily followed by the failure of the adjacent spans. A truss or girder bridge seems much better suited to such conditions, for sinking or tipping of one pier may and frequently does occur without injuring the superstructure.

One further point may be referred to here, in connection with the Paterson bridges. This is the manner of failure of the West St. bridge, in which an entire longitudinal or ring section of two arches fell, and in falling separated on a clean vertical plane from the remainder of these spans. This plane of parting was undoubtedly the plane separating the sections which were concreted on different days. The failure shows that the concrete did not form a monolithic arch-ring, but contained longitudinal planes of weakness. It would be a simple matter, no doubt, to bond such separate adjacent sections together by inserted transverse members of steel; but the necessity for this is not always recognized. The present case may serve as a reminder that "monolithic concrete" is not always so monolithic as the absence of visible joints may lead one to suppose.

The motormen employed by the Interborough Rapid Transit Co. of New York city are threatening to strike because of the physical examinations required by the company. As will be remembered, this company operates the lines of the Manhattan Elevated Ry., all of which are now equipped with electric traction. Trains of three to six cars are run, so closely spaced that the motormen must be constantly on the alert to avoid chance of collision with the train ahead. This company, moreover, will in a few months begin operating the Rapid Transit system, where trains will be a part of the time underground in tunnels and a part of the time on elevated structures, and the demands on the eyesight will be very great.

Manifestly, under such circumstances the company is justified in establishing and maintaining strict examinations of its employees' physical condition. If it did not do this it would fail in its duty to the public.

It may of interest to see what requirements the Interborough Co. has established for its employees. As furnished to us by an officer of the company, they are as follows:

I. As to eyesight:

The applicant must possess normal acuity of vision. Defects due to errors of refraction or causes that admit of correction by proper glasses are no bar to qualification. Total blindness in one eye or defective eyesight due to diseases that do not admit of repair, is sufficient to disqualify an employee. Vision is tested by means of Snellens Test Types, the accepted standard used by oculists and medical examiners in general, consisting of black letters of varying lengths on a white background that must be recognized distinctly at distances varying from ten to two hundred feet, in ratio and proportion to size of letters.

II. As to hearing:

Ability to understand and recognize words and their meaning, spoken in an ordinary conversational tone of voice at a distance of fifteen feet with back to the examiner is regarded as a satisfactory test of the sense of hearing. When the necessity arises, each ear is tested separately, as well as together, by means of the watch, the tuning fork and the Galton Whistle, in order to determine the degree of perception as to pitch, tone and intensity as well as the capacity to recognize the nature and character of the noises incidental to occupation.

III. As to color sense:

It is required that the person to be examined shall not only recognize, but also understand the use and the names of the colors red, yellow, green and blue. Those who possess insufficient perception to recognize fewer than three colors or who confuse red and green and yellow to an extent incompatible with the recognition of the red light at a moderate distance, are regarded as disqualified for service as motormen or engineers. The test for color blindness is made by the use of the colored worsteds of Holmgrin and by vari-colored lights by means of Dr. Williams' lamp.

IV. As to general physical condition:

It is required that the candidate shall be in good physical health and free from any grave organic or valvular disease of the heart.

We fail to see anything whatever in this list of requirements to which the employees can raise any reasonable objection. These rules are as necessary for the protection of their own lives and limbs as for the protection of the company's passengers. If the leaders of the motormen who think the examinations are too severe, will examine the "Proceedings of the American Railway Association," they will find in the last published volume the results of a detailed inquiry as to the practice of American railways in examining their employees. It there appears that out of 128 American railway companies who answered the circular of inquiry, every one of any considerable importance, with the sole exception of the Missouri Pacific and Central Vermont,* requires its engineemen to submit to examinations as to their eyesight.

Besides this, on nearly every important railway, tests of color perception, and of hearing, are made. All the appliances in use by the Interbor-

*These two roads reported that they were about establishing a system of examination.

ough Co., mentioned above, are in common use in steam railway examinations.

It is true that in electric railway practice the happy-go-lucky system, or lack of system, still prevails to a large extent and to that very fact is to be laid not a few of the appallingly frequent accidents on electric railways, particularly on lines which are attempting to operate at steam railway speeds without the safeguards that steam railway experience has proved to be necessary. In objecting to the examinations the Interborough motormen are clearly in the wrong. Any man with defective eyesight or color perception, or weak sense of hearing or heart disease has no business handling the levers that move loaded passenger trains on an elevated railway.

The negligence of many cities in looking after revenues from franchise companies is well illustrated by the facts and allegations brought out in a recent report to Mayor Low, by Mr. Robert Owen, one of the commissioners of accounts for New York city. The contract under which the electrical subways in Manhattan Borough were built provided that the city should receive all net profits of the company in excess of 10 per cent., but no adequate provision seems to have been made for the accounting necessary to enable the city to determine what was due to it, and apparently no provision whatever was made to safeguard the city against doctored accounts. Anyhow, Mr. Owen reports that in his opinion the yearly deficits reported by the company operating the electrical subways should be profits instead, and that the city is entitled to revenue, whereas it has never received a cent. Large blocks of stock on which only 1 per cent. was paid in cash were charged to construction at par, and similar charges were made on account of mortgage bonds at heavy discounts issued in payment for work done by a construction company. This company, also, was paid on the basis of cost, plus 15 per cent. Mr. Owen, for these and other reasons, deducts $3,290,000 from the construction cost of $7,492,000 submitted by the subway company on Jan. 1, 1903. By means of such deductions he makes out that the earnings on actual cash investment have been sufficient to entitle the city to a share in the profits of the company. Into the details or the merits of this controversy we do not propose to go. It merely serves as a fresh illustration of the folly of basing payments for municipal franchises on net earnings, and at the same time exercising no public supervision over the accounts of the franchise company. It is because of the opportunities for juggling accounts thus afforded that gross rather than net earnings are a preferable basis for reckoning municipal revenues from franchise companies, at least unless there is effective public control of capitalization and accounting and full publicity of accounts.

The failure of a large derrick at Lincoln, Ill., was described in our last issue, and a sketch was given to show the faulty design. We have since received the following supplementary description of the mast and horizontal boom:

The mast was constructed of three built up members, each member being composed of two 6 × 14-in. timbers bolted together and spliced so that three lengths constituted one stick or member. The center member stood perpendicularly and one on each side was sprung away from the center one in the middle. The boom consisted of two 12 × 14-in. red cedar timbers 86 ft. long.

In view of the facts that we have already given regarding the construction of this derrick, the testimony before the coroner's jury is of interest. The following is extracted from the local newspaper reports:

At 2 o'clock Wednesday afternoon Coroner Boyden completed the inquest regarding the death of Albert Sutter, who was killed by the fall of the court house derrick. Testimony introduced by H. C. Miller, Frank Wilder, Frank Glenfield and James Ross showed that the accident was largely due to a defect in the "hog chain" and exonerated the contractors and all others from blame.

The jury returned the following verdict:

"We on oath do find that James Sutter came to his death by a fall in the collapse of the derrick used in the construction of the court house at Lincoln on the 7th day of October, 1903."

In testifying before the coroner's jury, the superintendent of construction for the contractors is quoted as follows:

He had known of derricks in use of the same construction as the one used here and that the brace rods which gave way were one-half an inch larger than were usually used for derricks the size of the one in use here; that the arms suspended from the mast of the derrick weighed about 3,000 lbs., and so far as the weight of the arm was concerned one of the braces would easily have held it if, when the one parted, the arm had not twisted and thrown off the other supporting rod. His orders from the company were to spare no expense to make the derrick safe. These orders had been carried out.

It will be noted that no mention is made of the length of the king-post used in trussing the mast, the depth of truss being evidently a matter of slight moment in the eyes of the witness. As a matter of fact, we are informed that the depth of this king-post was 20 ins. With the data now at hand it will be interesting to determine the approximate stress in the rods used in trussing the mast, due to the dead load of the boom alone. The two 12 × 14-in. × 85-ft. sticks of the boom contained 2,380 ft. B. M., so that, assuming a weight of 3 lbs. per ft. B. M., we have a dead load of approximately 7,000 lbs. for the mast.

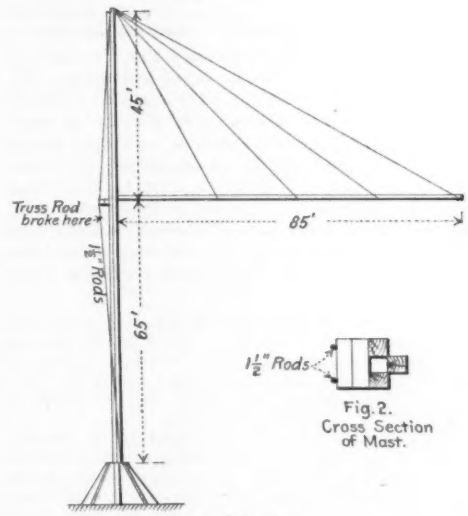


Fig. 1. Elevation of Derrick.

Fig. 2. Cross Section of Mast.

Referring to Fig. 1, we see by inspection that the horizontal thrust of the boom tending to bend the mast will be about equal to the weight of the boom, or say 7,000 lbs. According to the description of the mast above given, there were three 6 × 14-in. sticks, side by side, and not arranged as shown in Fig. 2. With a king-post 20 ins. deep, the distance from the center of the 14-in. mast to the center of the 1½-in. truss rods was $20 + \frac{14}{2} + \frac{1.5}{2} = 27\frac{1}{4}$ ins. Since under great stress the neutral axis in the timber would move toward the compression side, we may say that the effective depth of this truss was certainly less than 27 ins., or 2¼ ft. We have, therefore, this equation of equilibrium in the trussed mast:

$$2\tfrac{1}{4}\ x = \frac{65}{45 + 65} \times 7{,}000 \times 45,$$

from which $x = 82{,}700$, in round numbers; x is the stress in the two 1½-in. truss rods. These two rods have a combined cross-section of 3.53 sq. ins., hence the stress in these rods due to the dead weight of the boom alone was,

$$82{,}700 \div 3.53 = 23{,}400 \text{ lbs. per sq. in.}$$

This, it will be remembered, is upon the assumption that the timber in the boom weighed 3 lbs. to the ft. B. M., but it may have been somewhat more or less. The weight of the iron track on the boom is not included, neither is the weight of the trolley, and the hoisting gear, which included a hoisting block loaded with a 400-lb. weight. There was doubtless an additional stress in the rods due to their having been bent cold over the king-post block. If the rods were welded or if the net section had been reduced by threading without upsetting, there were, of course, sections of less effective area and less strength than that of the assumed 3.53 sq. ins. of iron. In any case, a stress of even 23,400 lbs. per sq. in. is dangerously near the elastic limit of iron; and any vibration or jarring of the huge boom would produce an impact stress that might easily break one of the rods. Moreover, this breaking of one of the rods might also have been brought about by the yielding of the wood under the king-post bearing of the other rod, so as to throw more strain on one rod than on the other. Viewed from any light it is apparent that this derrick was designed entirely by rule of thumb, and a pretty poor thumb at that, so that its failure was foreordained.

RECENT REVELATIONS CONCERNING TRUST FINANCIERING.

The investigation of the affairs of the moribund shipbuilding combination, which has been in progress in New York city for some weeks, reveals a record of financial mismanagement that has seldom been equaled. It has frequently been said that difficulty would be found in finding business men of sufficient mental caliber, executive ability and good judgment to manage the great industrial consolidations. Actual experience shows that those trusts which have been wrecked have gone down because the men in charge of their promotion and financial management had a moral standard little better than that of highway robbers. Their whole aim and object appears to have been to delude the public into buying stocks and bonds at a price far above their real value. That they had any responsibility, legal or moral, toward these purchasers or toward the public, seems never to have entered their heads.

It would be amusing, if it were not so serious—to recall how this band of trust organizers have posed as oracles, as philanthropists, as the creators of a new era in finance. The trust movement, they have declared, would benefit the public, the consumers, the employees, the owners of stocks and bonds, and they have professed to be influenced by the highest philanthropic motives in their huge promotion schemes. In the sequel it appears that they were simply and solely bent on making money for themselves by the very old scheme of selling something at a price far beyond its real value, and deceiving the purchasers by out and out lies in order to make the sale.

It is commonly said that the collapse of the market for industrial stocks, and the fact that the organization of trusts has apparently come to an end will put a quietus on any legislation for the regulation or suppression of trusts.

Practically this may prove true; yet the fact is that the revelations of the internal frauds in the trust organizations ought instead to lend greater force to the agitation for legislation upon this subject. It is said that the law cannot prevent investors from buying worthless stocks, and that it is not the business of the Government to look after investors anyway; but this is a most superficial view to take of the matter. The law can and does protect property-rights. Any government which did not give such protection would be unworthy the name. Has not the owner of an interest in a mine or a mill or a railway as much right to legal protection as the owner of a farm or a stock of dry goods?

A great proportion of manufacturing industry has now passed into the control of huge corporations. Is it a matter of slight importance to the country how these vast properties are administered? Is it not a public calamity if they are so managed as to debar the bona-fide honest investor from participating in their ownership and to make it certain that their ownership and control shall be left solely in the hands of speculators?

Even if the too common view that the investor must look out for himself be accepted, we must not overlook the fact that the management of these concerns is a thing of vital importance to many others besides their stockholders. Take the communities in which mills are situated, the army of employees dependent upon them for daily wages; consider also the higher class of employees—the overseers, superintendents, managers, engineers. Does it make any difference to these people whether the directorate of a company is made up of competent and honest business men, or whether it consists of a few unscrupulous trust

promoters, aided and abetted by well-meaning incompetents and insignificant automatons who hold offices and comply with the forms of law without more actual assumption of responsibility than so many parrots?

To ask such a question is to answer it. It does make and has made a great difference to thousands and tens of thousands. Of what avail is faithful service or efficient work in a business which is carried on as a speculator's football? It may be and not seldom has been the case that what the financial interests in control wanted was not efficiency but inefficiency. Do anything and everything to cut down profits, and bankrupt the property. The insiders could make money by bearing the stock market; and when honest investors have disposed of their stock at any price, appreciating that they were at the mercy of a set of unscrupulous swindlers, these same insiders could buy the property at a price far below its real value.

It is a fact that in not a few of the trusts the best and ablest managers, superintendents, engineers and members of the technical staff have resigned and gone into other work rather than continue under such management, such uncertainties and such callous disregard of personal interests as the trust organization frequently brought.

It is facts like these that make the consolidation of industries a matter of the gravest public concern. The mere circumstance that the price of stocks has fallen far below the level of a year ago has not abated a single one of the evils, or lessened one iota the need of effective legislation for their remedy.

As to what form that legislation should take, it is enough at present to say that mere "trust-busting" schemes, such as are frequently put forward by demagogues, promise, in general, harm rather than good. The wisest and ablest students of the problem are in agreement with Judge Grosscup of the Federal Bench, who, in a recent speech at Chicago, placed his finger on our corporation laws as the real source of the evils of which complaint is made. The so-called trusts, as well as every other incorporated company, are the creatures of law. Without the law they could not do business for a day. Surely, then, it is within the powers of law to dictate the form of organization under which capital may associate and to erect such safeguards as experience has shown to be necessary for the protection of the public and of those who entrust their property to the managers of the enterprise.

FURTHER LIGHT ON THE NEW YORK 1,000-TON BARGE CANAL PROJECT.

We published in our last issue a symposium giving the opinions of a dozen well-known engineers on the question: "What Action Should the Voters of New York Take with Respect to the Proposed Barge Canal?"

The letters which we print below were received in response to the same circular letter requesting an opinion, but too late for insertion in our last issue.

Mr. A. W. Robinson, who writes the first letter, although now resident in Canada, was for many years in Milwaukee, Wis., where he was Chief Engineer of the Bucyrus Co. He has had a very large experience, in connection with machinery and methods of waterway improvements, and is now Consulting Engineer to the Department of Public Works of Canada. Mr. Robinson holds membership in the American Society of Civil Engineers, the American Society of Mechanical Engineers, and the Canadian Society of Civil Engineers. His letter is as follows:

Sir: I have your letter of Oct. 3, in which you ask my opinion on the question, "What action should the voters of New York take with respect to the proposed barge canal?"

I do not feel called upon at this time to advise the voters of New York on this question. I can hardly agree with you that it is wholly a question of engineering. I think that the engineering side of this question has been already covered and that it is now a business question rather than an engineering one, between the transportation interests of the state of New York and the people who have to pay for it. There has been much discussion of the subject by engineers which has been wide of the mark as they do not take into question the commercial considerations, nor the question whether if such and such a canal be built it will be fully made use of by the transportation interests and be what they want.

My own opinion is that the day of small canals for the long-distance bulky traffic, such as we have in America, is ended and that the large canal would be more economical and will have the added advantage of enabling the large type of lake vessels to reach tide water. From the head of the lakes to Europe there should be but one place to break bulk, and that is at tide water. I can see, however, no advantage in the argument that the lake vessels can, by such a canal, be enabled to engage in salt water trade during the winter, and thus be continuously employed. I do not think there is anything in this, and that few, if any, of them would engage in such traffic.

Very truly yours,
A. W. Robinson.

14 Phillips Square, Montreal, Canada, Oct. 24, 1903.

We also submit the following letter from Mr. N. H. Hutton, M. Am. Soc. C. E., of Baltimore. Mr. Hutton is President of the Harbor Board of Baltimore, and has held a prominent position as engineer in connection with various waterway enterprises. He was formerly in charge of the Western Division of the Virginia Central Waterway and was Consulting Engineer in connection with the surveys of the proposed Pittsburg & Lake Erie Deep Waterway and the proposed ship canal from Philadelphia to New York. Mr. Hutton's letter follows:

Sir: Referring to your favor of Oct. 2, I would say: An increase in the dimensions of the waterway between New York city and the Lakes which would permit the passage of the average Lake steamers at a rate of speed not less than five miles per hour would, in my opinion, be very greatly to the benefit of your city.

I am also of opinion that no scheme involving transfer of cargo at the Lake ports would justify any large amount of expenditure on the canal. Investigations made by the Board of Consulting Engineers for a ship canal from Pittsburg to Lake Erie (of which I had the honor to be a member) indicate that a depth of waterway of 15 ft. will accommodate a majority of freight steamers on the Lakes. The possible rate of speed in a canal being dependent on the area of waterway, my observation and experience, has convinced me that the depth of water under the bottom of the vessel is a most important function in determining the necessary area—and a liberal allowance in this respect will permit of very considerable reduction of width, while allowing greater speed, with accuracy of steering and decrease of washing of banks.

Yours truly, N. H. Hutton.

Baltimore, Oct. 26, 1903.

Finally, we wish to bring forward testimony from a foreign source. A great deal has been made by the barge canal advocates of the fact that in Europe canals are still largely used and are being extended. No mention is made of the fact, however, that the European canals are for the most part shallower than the present Erie Canal, and even the largest waterways now under construction are very little deeper than the Erie Canal in its present condition.

We have recently received a copy of a paper presented to the Institution of Civil Engineers of Great Britain by Mr. L. F. Vernon-Harcourt, well known as one of the leading English engineers in connection with water transportation works, and author of a recent treatise on "Civil Engineering as Applied in Construction." Mr. Harcourt's paper was a review of the proceedings of the Ninth International Navigation Congress, held at Dusseldorf, Germany, in 1902, and of the important works visited by the Congress. In the course of this paper he described the new Dortmund-Ems Canal, completed in 1899, and also the Elbe-Trave Canal, opened in 1900. We quote as follows from this paper:

The total length of the waterway between Dortmund and Emden, is 168 miles; and the branch to Herne is nearly 7 miles in length, which it is proposed eventually to extend to the Rhine at Ruhrort. The canalized, regulated, and open Ems occupies about 58 miles of the length, the remainder constituting the canal proper.

The canal has a depth of 8½ ft. and a bottom width of 59 ft., *which are the standard dimensions determined upon for the future extensions of waterways in Germany.* The locks in the upper part of the canal have an available length of 220 ft., a width of 28½ ft., and a depth of 10 ft. on the sill, accommodating a single barge; whilst the locks of the three lowest reaches of the canal, and in the canalized Ems, are 541½ ft. long and 33 ft. wide, so as to be able to receive two barges with their tug. The ordinary barges navigating the canal can carry 400 tons and 600 tons of cargo; but special barges have been built of the largest dimensions which the canal can admit, 220 ft. long, 27 ft. beam, and 6 ft. 7 ins. draft, carrying 950 tons. Sea-going lighters also, 197 ft. long, 26¼ ft. beam, and carrying 1,000 tons of cargo, with a draft of 8½ ft., coming from Bremen, Hamburg, and Baltic ports, enter the canal after reducing their draft to 6 ft. 7 ins. by the removal of 200 tons to 300 tons of their cargo.

. . . . . .

The length of the Elbe-Trave canal between the Elbe and Lübeck is just under 40 miles.

The canal has a bottom width of 65⅝ ft., a width at the water-level of 104 ft., and a depth of 8½ ft., which is liable to be reduced in the top reach during dry weather to 6 ft. 7 ins. The section of the canal is very similar to that of the Dortmund-Ems Canal, having a slightly greater bottom width; and it is in conformity with the standard dimensions fixed for new German waterways.

In further confirmation of the above statements regarding the size of the latest European waterways, we would refer to the report of the Greene-committee of 1899 on the New York canal problem. From the portion of that report referring to European canals we quite the following:

The Dortmund-Ems Canal was undertaken by the Emperor to connect the large coal and steel-making districts of Germany with the North Sea at Emden. It is designed eventually to connect with the Rhine near Oberhausen, and also by a lateral canal, to be built from a point near Munster, to connect the Rhine with the Elbe. The distance from Dortmund to Emden is about 170 miles, and at different points along the route the Ems River has been canalized. The scheme of the canal has been to make it as straight as possible, with wide curves, so that long boats can be utilized. The work is of the most substantial character, and as it is the most recent large interior canal complete in Europe, it has all up-to-date improvements. It accommodates boats about 223 ft. long, about 29½ ft. wide, drawing about 7½ ft. of water, with a cargo capacity of 1,000 tons. These boats are built of steel, and cost about $5,000 each. At present they are towed by small tugs, but experiments are being made for electric haulage. . . . . .

In Germany they are working up to a standard of a boat with a capacity of 1,000 tons. They seek to obtain this capacity by the length and width rather than the depth of the boat; in other words, with longer locks and broader curves. They claim this is cheaper than a deeper canal.

It appears to us that the facts here presented constitute overwhelming proof that the proposed expenditure of $101,000,000 for a 12-ft. barge canal, *which would be nothing but a canal*, would be an expenditure in the highest degree unwise.

Suppose for the sake of argument that the running of 1,000-ton barges would do all that the advocates of canal improvement claim. The experience on the latest German canals absolutely proves that barges of this capacity can be built and operated with a depth of water only a trifle greater than that in the present Erie Canal. Why, then, spend $101,000,000 to make a new channel only a little deeper than the present canal, and capable of carrying boats only a little larger?

In the light of these facts the argument of the barge canal advocates that the defeat of the $101,000,000 appropriation means the abandonment of the Erie Canal is a transparent absurdity. If New York wants merely a canal from the Lakes to the Hudson, necessitating transfers at each end, the present Erie Canal, when put in good repair and equipped with improvements of moderate cost can do everything that has been claimed for the 1,000-ton barge canal.

If, however, New York or the nation chooses to recognize its opportunity, it can for very little more than is now proposed to be expended on a ditch for canal boats only, construct a waterway that will give the Lake shipping access to the seaboard and avoid the transfer charges that now constitute a large proportion of the cost of transportation.

A COURT DECISION ON PATENTS ON ALUMINUM PRODUCTION PROCESSES.

A notable patent decision has just been recorded by the United States Circuit Court of Appeals for the Second Circuit, relating to patents for aluminum production. The case in question was that of the Electric Smelting and Aluminum Co. vs. the Pittsburg Reduction Co., and the decision is in favor of the plaintiff, reversing the decision of the lower court.

As many of our readers will remember, the Pittsburg Reduction Co. has for a dozen years and over held a monopoly of the business of alumi-

num production. The company was founded in 1889 to operate the famous Hall process of making aluminum, invented by Mr. Chas. M. Hall while a student in college. Among its organizers and leading spirits for many years was the late Capt. Alfred E. Hunt, of Pittsburg, whose papers on the subject, published in Engineering News in the early '90's, will be recalled by many of our readers.

In the early years of the operation of the Hall process, bitterly contested patent litigation was carried on between the Pittsburg Reduction Co. and the Cowles Electric Smelting and Aluminum Co., of Lockport, N. Y., resulting in a victory for the Pittsburg Co., which established the Hall invention as a distinct advance in the art, as, indeed, practical experience has fully demonstrated.

In the present suit, action was brought against the Pittsburg Reduction Co. on the ground that its process of aluminum production infringed Patent No. 468,148, issued to Charles S. Bradley, on Feb. 2, 1892, after the Hall process had been in commercial use for several years, but the original application for which was filed Feb. 23, 1883, or nearly nine years earlier.

The Bradley patent contained a broad claim for the reduction of a refractory metal from its ores by first fusing the ore by the direct heating action of the electric current and then electrolyzing the fused mass. Bradley proposed to conduct the process in a heap or mass of the ore itself instead of using a refractory crucible, subjected to external heat; and the process was actually worked commercially in a small way for a short time.

The Hall process as originally worked used pots which were externally heated in a furnace; but the plan was soon adopted of using the electric current to fuse the material, whether as an independent invention is not certain. In doing this, however, the court holds that infringement occurred of the prior patent to Bradley. It says:

> Bradley's patent discloses a meritorious process for producing aluminum in large quantities, the essential features of which are, first, dispensing with external heat, and, second, the use of the same electric current to produce and maintain fusion and electrolyze the ores of aluminum. We are unable to discover anything in the prior art describing this process or anything closely approximating thereto. The patent is, therefore, not anticipated and its claims are entitled to a liberal construction.
>
> The judge of the circuit court, after careful and painstaking research, reached the conclusion that Bradley had made a valuable invention, but he failed to grant relief to the complainant upon the theory that the process which the defendant uses was an entirely separate invention, neither dependent upon nor subsidiary to the invention of Bradley. In this we think there was error. Hall's achievement should be considered in the light of an improvement upon Bradley's fundamental discovery.
>
> There can be little doubt that the defendant's process is a valuable one, and that to it is largely due the cheap aluminum of the present day. There is not the least disposition to detract from the merits of Hall or minimize his contribution to the art. Indeed, it may be conceded that, if the novel features so introduced be secured by a valid patent, he can hold the monopoly against all, Bradley included. This concession does not permit him, however, to appropriate the broad invention. He does not acquire the right to use the Bradley process simply because he has improved that process. He is entitled to enjoy what is his, but in doing so he cannot appropriate the property of another. The record discloses nothing unusual in this regard. It is rarely that an invention develops ultimate perfection in the hands of the inventor. The test of actual use discovers defects to be remedied and suggests improvements to be made. If the inventor produces a new and useful result he does not lose his reward because he, or someone else, subsequently renders it more useful.

After reviewing the various contentions in the suit, the Court, composed of Judges Wallace, Lacombe and Coxe, orders a decree against the defendant company for an injunction and accounting, with costs.

It will be noted that the above decision does not affect the validity of the Hall patent for the use of cryolite as a solvent for alumina. On the contrary, it more firmly establishes it. Nor can there be any doubt that it was the Hall invention whose successful exploitation made aluminum a commercial metal. The situation is simply one which constantly recurs in the history of inventions, in which an inventor whose work reaches commercial success finds that he must settle with the owner of some earlier pioneer patent, whose claims are entitled to a broad construction.

A SMOKE-PREVENTING STEAM-JET device designed by Mr. James C. Blaney, Chief Boiler Inspector, Chicago, is being applied to a number of plants and has proved very successful. There is no patent on the device, and the jet consists simply of a piece of ¾-in. pipe with the end closed to a 1-32-in. opening.

LETTERS TO THE EDITOR.

A Method of Making a Blue Print From a Blue Print.

Sir: Allow me to suggest a means of making a blue print from a print. Make up a solution of:

Water	9 oz. (fluid)
Stronger ammonia	1 oz. (fluid)

Saturate the blue print with this solution until the blue fades away, leaving white paper, then, after rinsing, apply with a sponge or by immersion the following solution:

Water	12½ oz. (fluid)
Tannic acid	2 drachms = 120 grains

The print will then become a dark brown in about 10 or 15 minutes. I have found this to be a very satisfactory method of getting brown prints with ordinary blue print paper, where the results pay for the labor involved. Hoping this will prove to be of value to your readers, I am, Yours truly,

W. Allen Bartels.

231 West Third St., Erie, Pa., Oct. 22, 1903.

The Advisability of Using Brown-Print Paper Instead of Blue-Print Paper for Copying Drawings.

Sir: Referring to your issue of Oct. 15, about making sun prints from blue prints, the writer would make the following additional remarks on the subject. Sometimes an ordinary blue print can be used as a negative. The time for printing is very long. If all the lines are traced over with the semi-transparent varnish it will be better, but is more labor than tracing on cloth or paper. But the writer for several years has used extra light-weight brown paper for all prints to be mailed. The postage is reduced and the thin prints can be used as negatives. If used with ordinary blue-print paper, the prints have blue lines and white ground. If used with brown paper the lines are brown on a white ground. The brown-print paper can be purchased from any of the leading stationery and engineers' office supply firms at about the same price as good quality blue-print paper. If manufacturers and contractors were to request engineers to use thin brown paper instead of blue paper when making prints to send out, there is no doubt that this would soon become the custom. The blue print is so commonly used and the brown print is so new that the writer has met many engineers who have not heard of the latter. He, however, has used brown paper since 1898, and it had then been in use for some years. Engineer.

Chicago, Ill., Oct. 17, 1903.

More About the Tar and Cement Joints for Vitrified Pipe at Atlantic City, N. J.

Sir: I was much interested in the letter of Mr. Allen, published in Engineering News of Oct. 8, telling how tight joints in vitrified pipe were secured at Atlantic City, N. J.

It would be a matter of interest to those who are trying to get tight work in pipe sewers if you could secure and publish some additional details of this work. Questions naturally arise as to the consistency of the tar, the proportions of tar and cement used, the method of mixing, whether the cement overcame the adhesiveness of the tar so that the paste could be easily handled, whether the joints were caulked, and the cost of joints made in this way as compared with those made in the usual way with cement mortar. Yours respectfully,

E. W. Branch,
Engr. Sewerage Commission.

Quincy, Mass., Oct. 12, 1903.

(Acting on the foregoing suggestion we asked Mr. Allen to give us further particulars. This he has kindly done in the letter following this note. —Ed.)

Sir: In answer to the letter of Mr. E. W. Branch, submitted to me regarding the use of tar for pipe joints, I would say that the material is known as "raw pine tar," being quite different from the coal tar used for roofing, etc. It is of the consistency of molasses. As much cement is kneaded into this as is required to make a paste the consistency of putty. From the limited experience on our work this would appear to take about 25 gallons (worth approximately $2) to one barrel of cement.

To keep the tar from adhering to the hands in mixing the latter are dipped occasionally in kerosene oil. By this means trouble from sticking is effectually avoided.

The cost for material and labor in mixing is well in excess of that for joints of mortar, but in a wet trench there may be a corresponding saving in cost of pumping, as the work can be done under water. No calking tool is used for the paste, which is simply pressed into the joint with the fingers.

Credit should be given Mr. John H. Decker, Superintendent of the Atlantic City Sewerage Co., for first calling my attention to the advantages of this kind of joint.

Yours truly, Kenneth Allen,
Engr. and Supt. Water Department.

Atlantic City, N. J., Oct. 19, 1903.

The Design of the Seventh Street Eye-Bar Suspension Bridge at Pittsburg, Pa.

Sir: I have noted with interest the communication of Mr. Gustav Lindenthal, published in your issue of Aug. 13, in reference to the 7th St. bridge at Pittsburg. The design of this structure appears to me to be open to serious criticism on two points.

In the first place, the use of two consecutive spans of the suspension type does not appear to be good practice. Mr. Lindenthal styles this structure a "suspended arch," but a combination inverted arch and continuous girder would appear to apply more nearly in describing it. Two consecutive arches and two consecutive "inverted" arches or suspension spans, represent relatively extreme conditions of stability and instability, respectively, in the condition of the common pier supporting them. Assume, for example, two arches or suspension spans, equal in span and rise, and resting on a common pier. For dead load, and for live load covering both spans at once, this pier is subjected to a vertical load only. Now remove the live load from one span and there develops an unbalanced horizontal thrust at the end of the loaded arch or an unbalanced horizontal pull at the end of the loaded suspension cord. The pier in each case should be designed to resist this unbalanced horizontal force, considered to act in conjunction with the vertical reactions. For the arch, the point of application of this horizontal force is down near the bottom of the pier, while for the suspension structure it is at a considerable distance up from the bottom, making the design of the pier a simple matter in the former case, and practically impossible in the latter. In the bridge illustrated there appears to be no provision made in the size of pier for this unbalanced force, and it is apparently taken up by the stiffening truss of the adjoining span, which would of course offer considerable resistance by its tendency to hold to its original shape; this involves a certain movement of the top of the tower where the suspension cables are attached, but there appears to be no roller bearing at this point to relieve the tower of this pull, nor is there a pin at the base of the tower for it to rock upon. As stated by Mr. Lindenthal, electric cars do not use this structure at the present time, traffic being diverted therefrom at each end to the 9th St. bridge.

SEVENTH STREET SUSPENSION BRIDGE AT PITTSBURG, PA.
Gustav Lindenthal, M. Am. Soc. C. E., Engineer.

(Bridge built in 1884; Pittsburg side span, 165 ft.; two center spans, each 330 ft.; Allegheny side span, 165 ft.; truss span over Pittsburg & Western R. R. tracks, 90 ft.; total length, 1,080 ft.; width, 42 ft.; live load, 3,200 lbs., per lin. ft., of which 1,200 lbs. is unbalanced traveling loads.)

In the second place the use of duplicate cables separated to the extent that these are, and with a system of diagonals between, does not appear to be good practice, in that it involves a state of much indeterminateness in the stresses to which most members of the structure are subjected. Even assuming it possible to fabricate and erect the cables with sufficient exactness to make the stresses uniform in each at the start (of which I doubt the possibility) a change in temperature or even the imposition

of any vertical loading would immediately tend to throw more of the load into one cable than the other. Let it be assumed, for example, that the cables and web members of this structure have been erected in accordance with the designer's diagrams and details. Now let the temperature rise and the span be covered with a uniformly distributed load over its entire length. By the rise in the temperature every individual member, including cables and diagonals, tends to increase in length, and owing to this and to the effect of the live load the entire system has sagged appreciably at the center of span. But in assuming this new shape, many of the diagonals must be shortened instead of lengthened, especially near the ends of the span. There will be approximated the condition of a truss whose chords are the upper and lower cables, and whose span equals the distance between towers. Now as this truss sags it can be seen at once that one set of diagonals will be subject to compression increasing in amount going from the center each way to the ends, thus producing secondary stresses in the web system and cables which, when taken in conjunction with the effects of a possible unequal settlement of the piers, would be difficult of determining practically.

This structure is in reality a continuous girder, without sufficient web bracing to act as such altogether, and having the appearance of a suspension bridge. Under load it will act as a continuous girder as far as there is material to offer resistance to the stresses produced in the several members. If the web system were sufficiently strong to resist these stresses the bridge would be a continuous girder pure and simple. With the web system too light to offer sufficient resistance, the frame will distort by local failure of the web members and finally come to a state of equilibrium as a combination suspension structure and continuous girder. To quote Mr. Lindenthal himself (Eng. Magazine, December 1898) the bridge will be "safe" (in other words, the load will not drop into the river) "provided the cables, the towers, and the anchorages are strong enough," but this criterion seems hardly applicable in the solution of such an important problem.

It would be interesting indeed to see a diagram of loads, stresses, and sections of this bridge and the assumptions made in designing. From measurements that I have taken in passing, the cables have an area of about 50 sq. ins. each, top and bottom, whereas the web members are made up each of two eye-bars, 6 × ⅛-in., latticed, and reinforced by four 2 × 2-in. angles, to which the latticing is riveted, and having an available area of about 4-sq. in. pin-bearing surface each. The diagonals appear to be uniform in section throughout the span. The coupling together of these cables with their combined area of 100 sq. ins. tension value and the web system of 4-sq. in. pin-bearing value appears to be somewhat like hitching together an elephant and a pony to the same wagon; there is not much doubt which will guide the direction of their going nor which will suffer most when they disagree.

Yours respectfully, Chas. Worthington.

Farmers' Bank Bldg., Pittsburg, Pa., Oct. 12, 1903.

(A proof of the above letter was furnished to Mr. Lindenthal, who has favored us with the following reply.—Ed.)

Sir: Your correspondent is mistaken in assuming that the towers of that bridge must resist pull from the unbalanced live load. As a fact they do not, the chains having rocker bearings on the towers. The unbalanced, as distinguished from the balanced, portion of the live load, was assumed, as I stated before (in your issue of Aug. 13), at 1,200 lbs. per lin. ft. of bridge, which probably has never been reached yet in the 18 years of its existence. The unbalanced live load must of course be resisted by the stiffness of the arches. The loaded arch is subject to bending downward, and the unloaded arch or arches are subject to bending upward. The bridge would be amply safe for electric cars when not running and meeting in trains. However, there were no electric cars in Pittsburg when that bridge was built. Cars would have to run on the same tracks with the wagon trucks, which would delay them. The two neighboring bridges are wider and provide special tracks for rapid transit.

To a bridge engineer it is plain that the system of the Seventh St. bridge is statically indeterminate in the second degree, for which the strains are most readily determined with the aid of influence lines, a theory with which your correspondent, to judge from his reasoning, is probably not acquainted.

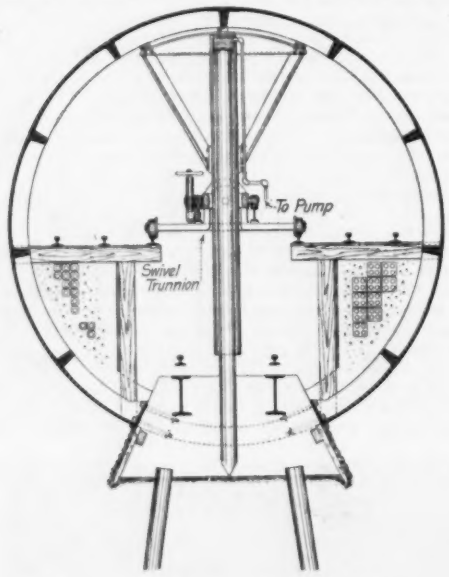
The cross sections of the chains and diagonals respectively are for the maximum stresses and were made uniform throughout the four arched spans, for the very good practical reason that it would not pay in such comparatively short spans to vary the sections from panel to panel in accordance with the slight differences in the theoretical values.

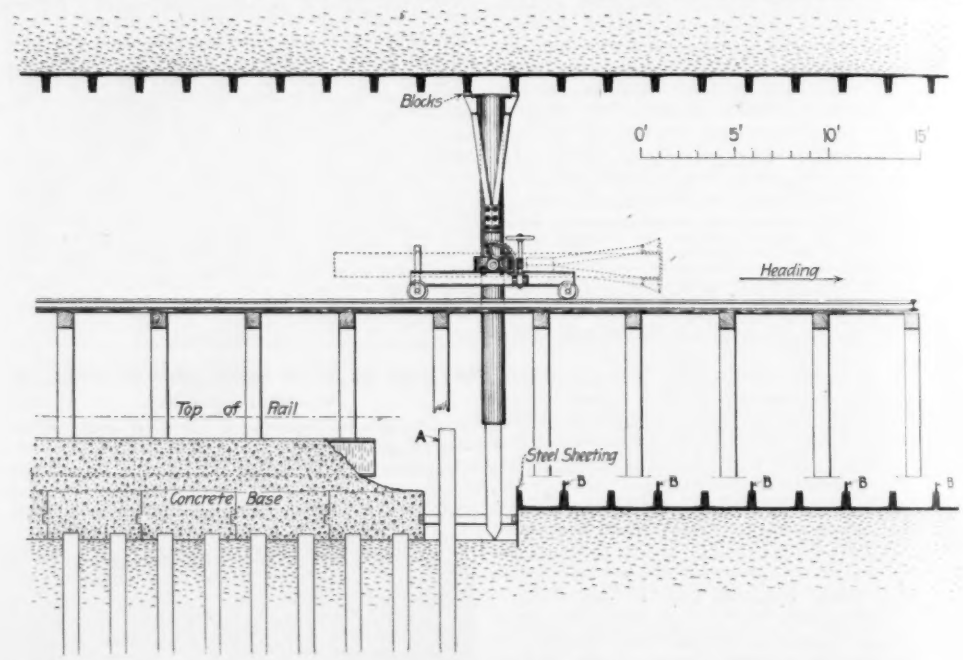
The chains form the chords of the suspended arch ribs, which, as explained before (in your issue of Aug. 13), act as if end-hinged. The maxima do not occur all at the same time, or in the same panels. For dead load and uniform live load, the chains require to have the heavier sections near the towers. Temperature-strains require heavier chord sections at the center of the two full spans, and the unbalanced live load requires the heaviest chord sections at the quarters of the two full spans and at the center of the half spans. For long spans, it would be worth while to save metal by varying the chain sections from panel to panel in accordance with theoretical requirement, but not in smaller spans.

So also with the web members. The heaviest web members would theoretically be at the ends of the two half spans and at the ends and middle of the two full spans. The minimum shop section was found to be heavy enough for them, although too heavy for the light sections, which should be in the middle of each half span and at the quarter of each full span. But lighter eye-bars than 6 × ⅛-in. were not obtainable, so the minimum shop section was adopted throughout. It seems that your correspondent, who believes that the bending and shearing strains in suspension and arch bridges resemble those in truss bridges, has yet much to learn in bridge engineering before essaying to discuss that intricate subject.

G. Lindenthal.

45 Cedar St., New York City, Oct. 22, 1903.





PROPOSED SYSTEM FOR DRIVING WOODEN PILES BY HYDRAULIC PRESSURE TO SUPPORT THE NORTH RIVER TUNNEL OF THE PENNSYLVANIA R. R.

Designed by J. W. Reno, M. Am. Inst. M. E.

An Alternative Plan of Pile Supports for the Pennsylvania R. R. North River Tunnel.

Sir: The official call for bids by the Pennsylvania R. R. Co. for its proposed tunnels under the Hudson River states that alternative plans will be entertained, provided they meet the following requirements:

1st. The shell of the tunnel must consist of a metal lining with concrete inside.

2d. The construction proposed must be in every respect equal in strength and efficiency when completed to that shown on the contract drawings, and under North River must have adequate support on piles or cylinders for the entire live load.

In your issue of Oct. 17 you publish a detailed description of the plans for this section, and I have therefore thought it would interest your readers to describe an alternative plan which I have designed. This plan does not vary from the official plan except in regard to the floor of the tunnel and the character of the pile support for the roadbed. The official plan proposes about 700 cast-iron screw piles, 27 ins. in diameter, spaced 15 ft. apart, longitudinally, screwed down through holes in the floor of the tunnel to an average depth of 60 ft. Experiments made by the company show that long cast-iron piles when subjected to a load of 100 tons, have a compression in the pile itself of ¼-in., and that the pile returns to its former position after the load has passed over it. For this reason it is proposed to carry the roadbed on the tops of these piles and to give it no connection with the floor of the tunnel proper. The pile, where it comes up through the floor, is provided with a long steel sleeve or stuffing box, in which it may move without strain to the tunnel lining. It seems to me that a better roadbed can be obtained by the plan shown in the accompanying drawings, which I will now describe.

The method of driving the heading is by the well known hydraulic shield system under compressed air. The floor segments of the tunnel in my plan are of special design, so that at a point about 100 ft. back of the heading they can be taken up in pairs.

In order to facilitate the taking up of the floor segments, the short key segment, instead of being at the top, is placed at the bottom of the ring, where it can be extracted by a screw jack. Each pair of floor segments is also provided with a beveled steel plate, shown at B, which can also be drawn out in order to free the segments. They are then carried by a trolley, suspended from the platform rails, to the heading, where they are used over and over again. A shallow excavation 5 ft. × 8 ft. is then made in this space and through the bottom six wooden piles are driven down to a depth of 22 ft., or 44 ft. if necessary. Upon the tops of these piles is laid a mass of concrete to conform to the inner line of the tunnel and in this concrete are set the anchor bolts to which the springer segments of the tunnel lining are fastened, as shown. This construction is carried on consecutively, pairs of segments being taken up and replaced with piles and concrete to any desired length. Upon this invert is then laid a pair of heavy longitudinal I-beams in 20 ft. lengths and a concrete filling about them is added to increase the rigidity. The motor proposed by the Pennsylvania R. R. I understand will weigh 100 tons and will be 30 ft. long upon a wheel base of approximately 20 ft. Under these conditions the steel concrete girder which I have described can be guaranteed to act as an absolutely rigid beam for the above length. If this foundation distributes the above weight equally over 24 piles, each pile will be loaded to the extent of 4 tons.

It is well known that the supporting power of a number of piles in soft ground is proportional to the area of their contact surface. It is therefore interesting to compare the surface area of the 18 wooden piles, distributed in the manner I propose, with the single cast-iron screw pile shown in the official plan. Assuming an extreme case of an iron pile, 100 ft. long and 27 ins. diameter, we have a surface area of 706 sq. ft. The aggregate surface area of 18 wooden piles, 10 ins. in diameter and 22 ft. long, is 990 sq. ft. or about 30% greater.

The official borings of the North River section show a homogeneous material from one side to the other, which does not appreciably change in character until bed rock

is reached at a depth of 200 to 300 ft. An examination of the borings shows a clay-sand material which would give admirable support to piles, such as I propose.

The method I propose for driving the piles within the tunnel is as follows: Upon each side of the tunnel, about on the center line, is constructed a timber platform as shown. The outer tracks are for the purpose of taking material into and out of the tunnel and would be operated by cable. The two inner rails are for the purpose of carrying the hydraulic pile driver shown in the drawings. This consists of a steel cylinder 12 ins. in. diameter containing a plunger which by the usual cup leather rings fits the bore of the cylinder. The cylinder can be turned into a horizontal position by the screw gear shown, and the pile, which will come delivered on the small railway, is pushed into the cylinder, butt foremost. It is then chocked in place and the cylinder inverted. The water pressure, 200 lbs., is then turned on and the pile pushed down into the position shown at A, under a pressure of 10 tons. The hydraulic cylinder is provided with a universal motion, being carried in two trunnion rings at right angles to each other. The frame of the trunnion also has a side play on its carriage which makes it possible to drive the two outer piles on a batter, as shown. The upper end of the cylinder is provided with a steel hood, which distributes the upward thrust over an area of 25 sq. ft. of the tunnel roof. As the downward pressure of the material over the roof for this area will be 77½ tons, I believe this is a perfectly safe procedure. It is proposed to finish the driving of the pile by an ordinary air pressure pile driver which will be carried on the track in the same manner as the hydraulic cylinder.

A very important advantage in this system is the fact that all these operations can be carried on without interfering with the transfer, back and forth, of the material from the tunnel heading and the operation of driving the tunnel and constructing the foundation can be carried on at the same time and under the same air pressure. A further advantage lies in the fact that the cast-iron floor segments which represent about one-sixth of the lining of the tunnel are replaced in my plan by much cheaper material of equal if not greater strength.

In regard to the stability of the structure as a whole I find by calculation that the weight of the ground which the tunnel and base replaces, amounts to 49,820 lbs. per running foot, and that the weight of the tunnel shell, base and live load altogether, weigh 49,200 lbs. per running foot, from which we see that the entire structure comes within 620 lbs. per running foot of being in a condition of equilibrium. Yours truly,

J. W. Reno.

555 W. 33d St., New York, Oct. 22, 1903.

THE EAST RIVER DIVISION OF THE PENNSYLVANIA R. R. TUNNEL AT NEW YORK CITY.

(With two-page plate.)

The North River Division of the Pennsylvania R. R. tunnel at New York city was described in detail in our issue of Oct. 16. In this issue we describe the construction of this line under the East River to Long Island. The total length of this East River Division of the tunnel if 2.85 miles and it is all four, six and seven-track line. In point of extent, therefore, the work on the East River Division ranks even higher than the more conspicuous task of tunneling the North River and Bergen Hill.

GENERAL DESCRIPTION.—The East River tunnel lines begin at about Seventh Ave., in Manhattan, and extend to Thomson Ave., in Queens. A map and profile of the line are shown by Fig. 1. As will be observed, there are two separate twin tunnel lines. These follow 32d and 33d streets in Manhattan to about Seventh Ave., where they curve northward and continue to the Long Island shore, gradually converging as they proceed until they meet in one open-cut structure. From Seventh Ave. to Fifth Ave. in Manhattan each tunnel will be a three-track concrete arch structure; from Fifth Ave. to a little beyond First Ave. in Manhattan each tunnel will consist of twin single-track tunnels, with concrete or brick and concrete lining; from First Ave. in Manhattan under the East River and to about East Ave. in Queens each structure will consist of twin, single-track, cast-iron lined tubes, and from the terminus of the tube section to the open cut the structures will be twin, single-track, concrete or brick arch tunnels. The relative lengths of these several types of structure are roughly indicated on the plan and profile of Fig. 1.

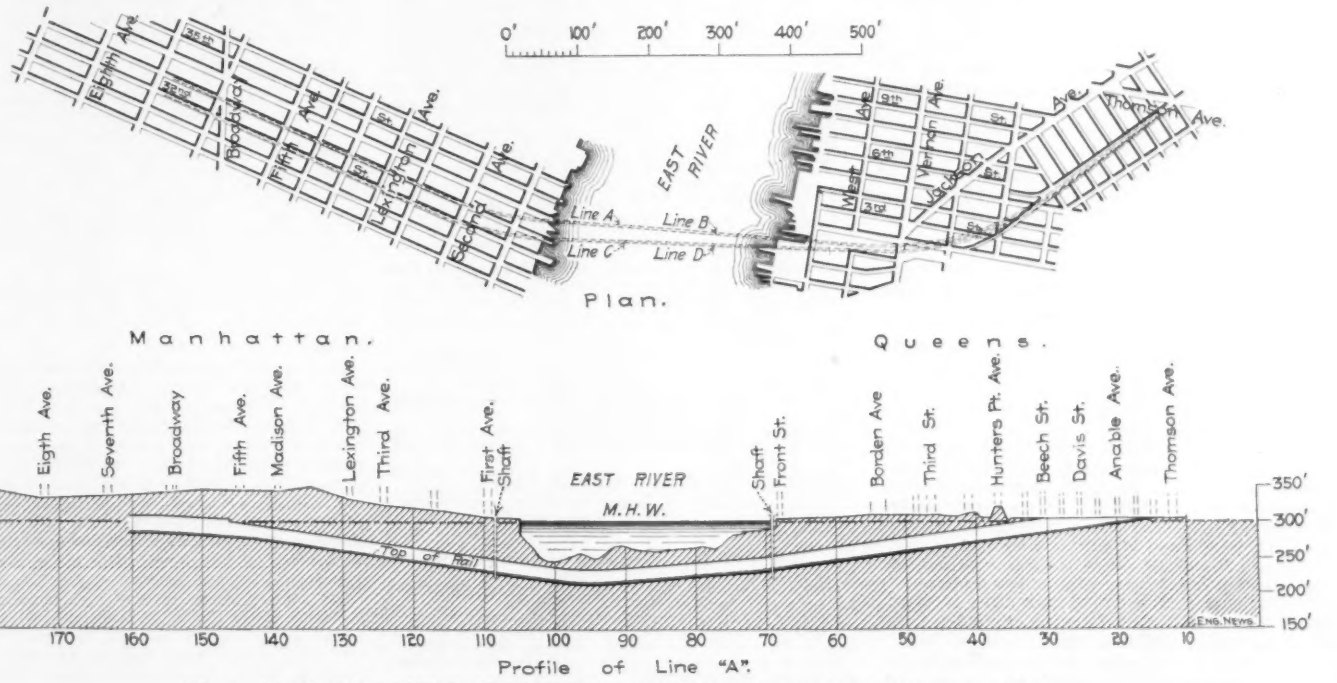


FIG. 1. PLAN AND PROFILE OF EAST RIVER DIVISION OF PENNSYLVANIA R. R. TUNNEL.

TWIN MASONRY ARCH STRUCTURE.—At Fifth Ave. the structure of each tunnel changes from the wide arch section just described to twin masonry arches constructed in one excavation, with a masonry dividing wall to about First Ave., and thence constructed in two excavations, with a rock core between, to the Manhattan shaft for the subaqueous tube tunnels. The total length of this section of the work will be about 3,575 ft. The character of the structure is illustrated by Figs. 4, 5 and 6. Figs. 4 and 5 show construction in one excavation with masonry dividing wall and concrete and brick roof arches, respectively, and Fig. 6 shows construction in separate excavation with rock core between. The drawings give all essential dimensions and classes of material.

TWIN TUBE TUNNEL.—The twin masonry arch structures just described terminate at the Manhattan shafts, just east of First Ave. From this shaft under the East River to about the intersection of Borden and East avenues in Queens, a distance of approximately 6,000 ft., each tunnel will be a twin tube structure. The drawings of Fig. 7 show the construction of this type of structure.

QUEENS LAND TUNNEL AND CUT.—From the end of the twin tube construction described in the preceding paragraph to the terminus at Thompson Ave., the work will consist of two twin masonry arch structures, merging into an open-cut approach.

SHAFTS.—To construct the East River section of tunnel there will be two shafts on each shore. The construction of these shafts are specified as follows:

The shafts near First Ave. in Manhattan and those in Long Island City will consist in part of steel caissons, Fig. 8, with double walls, the spaces between the walls filled with concrete. The caissons shall be sunk to a uniform bearing in rock, and when in final position shall not vary more than 6 ins. from proper position nor more than 3 ins. from level in any direction. If rock of suitable soundness is found above the highest point of the tunnels, the engineer may stop the sinking of the caisson. A water tight joint will then be made between the lower part of the caisson and the adjacent rock and the excavation of the shaft continued to a depth sufficient for the pump chambers and sumps to be provided for pumping.

If in any case rock of a suitable character on which to stop the sinking of the caisson is not found above the highest point of the tunnels, the caisson shall be sunk to such a depth that the openings formed in the sides above the working chamber for the egress of the shields will be at proper elevation. Sumps will be formed below the level of the tracks.

Excavation above the final position of the cutting edge of each caisson will be measured by the product of the horizontal area included by the exterior lines of the cutting edge of the caisson by the vertical depth of the excavation, no allowance being made for materials brought into the working chamber from outside of the caisson. Payment will be made for only the concrete and steel left in the completed work. In case the caisson is sunk as provided for in the preceding paragraph, the bulkheads in the tunnel openings and that portion of the middle wall indicated on the contract drawings as being removed after sinking caisson will not form part of the completed work and will not be included in the estimates for payment.

Below the final position of the cutting edge the excavation required is shown by the neat line on the contract drawings, and no rock excavation shall be left in place inside this line. Excavation outside of the neat line must be avoided as far as possible, but all loose or shattered rock must be removed. As a fair provision for unavoidable excavation outside of the neat line, it is assumed that the excavation will extend an average distance of 1 ft. outside the neat line on the sides below the final position of the cutting edge of the caisson, and 6 ins. below the neat line on the floor. These average distances are represented by the standard section line on the contract drawings, and it is understood that the price named in the contract for excavation is based on quantities defined by the said standard section line. No allowance will be made to the contractor for excavation outside the standard section line, nor will any deduction be made for material left in place between the neat and standard section lines. The engineer shall have authority to require that the excavation be enlarged below the final position of the cutting edge of the caisson, either while the first excavation is being made or at any time thereafter, and in such case the allowance between the neat lines of the complete excavation required and the standard section lines from which amount of excavation is to be calculated, will remain as above described.

If the engineer deems it necessary or advisable the sides and bottom of the shaft below the final position of the cutting edge of any or all caissons shall be lined with concrete, with or without embedded steel rods or shapes, as he may require. The amount of concrete shall be calculated from the standard section line, as in excavation, no addition being made for concrete required to replace rock removed outside the said line, or deductions for rock left inside the same, provided that no material remains inside the neat line.

The chamber roofs of the caisson may be removed either before or after erecting the shields, as may seem most expedient after completing the excavation and lining; but if removed, provision must be made and maintained for replacing any of them if it should become necessary while the tunnel is being driven. The roof of the working chamber, including timber and steel girders, will not form part of the completed work and will not be included in estimates for payment.

The working shafts in Manhattan near the East River are for joint use of contractors for the adjacent sections, and when completed the space in each opening shall be divided equally between them. A substantial fireproof bulkhead satisfactory to the engineer shall be built across each opening in the center, transverse to the axis of the tunnel, by the contractor for the river section, and shall be maintained during the work by the contractor for the section to the westward. The bulkhead shall be substantial, subject to the approval of the engineer, and shall extend from the bottom of the shaft upward to the top platform. The contractors for the several sections shall have equal rights for transfer of materials between shafts and the pier at the foot of 33d St.

CONSTRUCTION.—The construction work for the East River Division includes concrete and brick-lined tunnel and subaqueous tunnel with cast-iron lining. The materials used and the methods of work employed are exactly similar to those for corrseponding types of work on the North River Division, and as these were described in detail in our issue of Oct. 15, 1903, they will not be repeated here.

In conclusion it should be repeated that the plans for the East River Division are the work of the Board of Consulting Engineers. The work will be in the direct charge of Mr. Alfred Noble, M. Am. Soc. C. E., as Chief Engineer.

METHOD OF MAKING ANNUAL INSPECTION OF BRIDGES AND CULVERTS.*

GENERAL.—While the title of the subject apparently limits the report to annual inspections of bridges and culverts, your committee believes that a separate discussion of annual inspections would not be as effective as a thorough review of all questions affecting bridge inspection and hence has decided to treat the subject from a more general and exhaustive standpoint. The committee considers, however, that the report should be limited to the inspection methods employed by the regular bridge department and engineering officers in charge of the maintenance and improvement of existing bridges of an operated line of railroad and not to the inspection methods during manufacture and construction of new bridges.

SCOPE OF INSPECTION BY BRIDGE DEPARTMENT.—According to the organization and size of a railroad, the duties of the regular bridge department as far as inspection is concerned vary considerably. On some roads the bridge department inspects and reports on all classes of bridges, culverts, masonry, drains, buildings, etc., while on others the inspection is limited to bridges proper.

The answers received to the question as to whether culverts should be inspected by the bridge department, while varying in details and limited in some cases, indicate clearly that the general consensus is in favor of the larger size culverts being inspected by the bridge department.

The answers to the question as to whether the bridge department should inspect and report on the masonry and foundation of bridges indicate that the best practice would seem to be for the masonry and foundations to be considered as part of the bridge and hence falling within the sphere of the bridge department to report on.

The opinions in regard to the extent to which the track department should be relied on for the current inspection of bridges, masonry, and culverts, indicate that the general opinion would seem to be that the regular trackmen, on account of their being daily in the vicinity of such structures, should watch all bridges, masonry, and foundations in a general way, more particularly with reference to the waterway being kept clear and possible damage during high water, reporting promptly any defects they may note and taking such necessary steps as the emergency may require.

CLASSIFICATION OF INSPECTIONS.—Bridge inspections can be grouped in two classes, one in which the inspection is made by the division officials only, the other where a general railroad officer or a representative of such general railroad officer is present. This distinction applies practically to a railroad operating either under a division system or a department system.

The first class of inspection can be called "Current Inspection," its purpose being to keep the structure in safe condition, to promptly discover any defects, and to report same promptly so that repairs can be made before the safety of the structure is affected. In other words, current inspection embraces the inspection necessary to keep the structure at all times in a safe condition. This inspection furnishes to the division men in direct charge of the structure the necessary information to serve for their guidance in outlining the work to be done by the regular bridge maintenance forces. The inspection is made by a regular division bridge inspector, by a mechanic detailed from the bridge gang, by the bridge foreman, master carpenter or supervisor of bridges and buildings, right along at all times, or periodically on special monthly, bi-monthly, or quarterly trips.

The second class of inspection can be called "General Inspection," frequently called the annual inspection, although in many cases conducted semi-annually, or even quarterly. This class of inspection has for its object not only to check the work of the division organization, but also to make a more careful investigation of important bridges, to make suitable record of the general condition of all bridges and structures on the entire road, and further to ascertain and settle what extensive special repair or renewal work should be done in the following working season.

The general inspection is usually made by a representative of the chief engineer or engineer maintenance of way, such as the bridge engineer, general bridge inspector or assistant engineer, who passes over each division of the road in connection with the division men and makes a general inspection of all structures on the road.

In addition to current inspection and general inspection, there is a class of bridge inspection that might be designated "Special Inspection," where, owing to the magnitude and importance of the bridge, special bridge experts or consulting engineers are called in, or in case of the condition of a bridge being reported as doubtful a special inspection of same is ordered.

BRIDGE INSPECTION SYSTEMS.—A valuable tabulation is presented herewith, compiled by Mr. I. O. Walker, member of the committee, and Mr. Job Tuthill, of the Pere Marquette R. R., as to the various methods of bridge inspection in use on various railroads of the country.

BRIDGE INSPECTION METHODS.

Atchison, Topeka & Santa Fé, monthly by general foreman, yearly by superintendent and general foreman.

Bangor & Aroostook, monthly and spring and fall regular by superintendent bridges and buildings.

Bismark, Washburn & Great Falls, monthly by bridge superintendent.

Boston & Maine, fall by inspectors and supervisors.

Burlington, Cedar Rapids & Northern, frequently by division foreman, annually by division engineer.

Chicago & Alton, quarterly by engineer maintenance of way, semi-annually by chief engineer.

Chicago & Eastern Illinois, frequently by foreman, annually by superintendent bridges and buildings and foreman.

Chicago & Northwestern, September and April by division engineer and superintendent bridges and buildings.

Chicago, Burlington & Quincy, by bridge superintendent.

Cincinnati, New Orleans & Texas Pacific, monthly by superintendent bridges and buildings, quarterly by chief engineer.

C., C., C. & St. Louis, frequently by supervisor, annually by engineer maintenance of way.

Duluth & Iron Range, monthly by foreman, spring and fall by superintendent bridges and foreman.

Florence & Cripple Creek, monthly by supervisor.

Fremont, Elkhorn & Missouri Valley, annually by division engineer and superintendent bridges and buildings.

Houston & Shrevenort, semi-annually by superintendent and general superintendent.

Illinois Central, quarterly by bridge superintendent and foreman.

Intercolonial, annually by bridge inspector.

Jacksonville & St. Louis, monthly by bridge foreman.

Lake Erie & Detroit River, spring and fall by engineer and bridge foreman.

Lake Shore & Michigan Southern, spring and fall by general bridge foreman and principal assistant engineer.

Lehigh Valley, monthly by inspector, annually by bridge engineer.

Long Island, quarterly by bridge foreman, semi-annually by superintendent bridges and buildings, annually by engineer maintenance of way.

Louisville & Nashville, monthly by bridge foreman, quarterly by bridge superintendent, annually by bridge engineer.

Michigan Central, semi-annually by assistant bridge engineer and foreman, annually by bridge engineer.

Missouri, Kansas & Texas, frequently by inspectors and foremen.

Nashville, Chattanooga & St. Louis, frequently by bridge foreman and supervisor, annually by chief engineer.

N. Y. C. & H. R. R. R., continually by inspectors, quarterly by supervisor.

Norfolk Southern, monthly by supervisor, March and September by engineer maintenance of way.

Northern Pacific, January by superintendent bridges and buildings, September by division engineer and superintendent bridges and buildings.

Pecos Valley, semi-annually by general foreman bridges and buildings and inspector.

Penn. Lines West of Pittsburg, monthly by foreman, quarterly by master carpenter, annually by engineer of bridges.

Philadelphia & Reading, annually by bridge engineer and foreman.

Pittsburg & Lake Erie, frequently by foreman carpenter.

Santa Fé, Prescott & Phoenix, weekly by trackwalkers, semi-annually by chief engineer and general foreman.

Plant System, semi-annually by superintendent bridges.

Seaboard Air Line, spring and fall by bridge foreman and roadmaster.

Southern Indiana, semi-annually by engineer maintenance of way and superintendent bridges and buildings.

Southern Pacific, quarterly by inspector, foreman, resident engineer, and engineer maintenance of way.

Terre Haute & Indianapolis, spring and fall by master carpenter and engineer maintenance of way.

Toledo, Peoria & Western, annually by master bridges and buildings.

Union R. R. of Pittsburg, monthly by master carpenter, semi-annually by engineer and maintenance of way.

W. Virginia Central & Pittsburg, spring and fall by bridge foreman and engineer maintenance of way.

Wheeling & Lake Erie, continually by inspector, annually by chief engineer and superintendent bridges and buildings.

Wisconsin Central, semi-annually by division engineer, principal assistant engineer, and general foreman.

At the first glance, the data presented are confusing and apparently not indicative of much chance of clear deductions being drawn from the existing practice of railroads. After more careful study, however, and after making allowance for variations in the systems reported due to local conditions, special organizations, the varying size of roads and the density of their bridges and structures, certain general guiding principles underlying the general practice can be evolved and formulated.

Current Inspection: In regard to current inspection the fundamental principle is that all bridges and structures should be visited periodically by a competent bridge man, not necessarily an engineer, who examines all important parts, notes and reports the general condition and whether there are any defects requiring immediate attention or repairs during the current working season.

The division engineer or superintendent of bridges and buildings, in other words, whoever has general charge of bridge maintenance on the division or district, should watch these reports and act promptly on receipt of same, according to the emergency. He will necessarily, in important cases, make a personal supplementary examination and must keep himself advised at all times of the general condition of all bridges and structures under his control by frequent inspection trips over his territory.

For the information of the higher officers, both so as to keep them advised of the condition of the bridges and also what work is being done in the way of maintaining them, your committee considers it desirable that the division engineer or superintendent of bridges and buildings should make out a monthly inspection report, noting briefly the bridges inspected during the month and stating the general condition, any defects found or repairs required, and action taken or recommendation. This report should be simple and prepared for information and record purposes.

General Inspection: The guiding principle and purpose of a general inspection is to have same made by or under the direction of an expert bridge engineer, representing the chief engineer or other officer in general charge of bridges.

This general inspection, made annually, semi-annually, or quarterly (and on some railroads constantly by a regular general bridge inspector reporting to the chief engineer or other officer in general charge of bridges) serves not only to check up the work of each division but also makes a comparison between the various divisions possible and promotes uniformity in the standard of maintenance and methods. It should also determine what structures should receive extensive repairs or be renewed or replaced in the following working season. It serves further as a check on the general office bridge records, recording changes made in the existing structures, etc.

The general inspection is of such importance that the inspection notes should be thorough and should be embodied on a complete and full inspection report, going into much greater detail than in the routine current inspection.

RULES AND REGULATIONS FOR BRIDGE INSPECTION.—Your committee has considered the desirability of formulating a standard code or rules and regulations for bridge inspection, but has come to the conclusion that the different conditions and organizations on the various railroads preclude any one standard being applicable to all.

METHODS FOR PASSING INSPECTORS OVER ROAD.—The various methods employed for passing inspectors or inspecting parties over the road are shown in the appendix from the answers received to this inquiry. In general the best practice can be outlined as follows:

For current inspection on roads with comparatively few bridges and light traffic, the inspector works his way over the road on a light hand-propelled three-wheel velocipede. On roads with many bridges close together, the inspector can cover the territory on foot with occasional rides on passing trains or engines. On roads with dense traffic, especially in the eastern sections of the country, it is not considered good practice to allow promiscuous use of velocipedes and the inspector is obliged to work the various sections on foot with such assistance as he can obtain from trains and engines.

Where the inspection is made by the division engineer or superintendent of bridges and buildings, usually accompanied by the bridge foreman, bridge inspector, and sometimes by an extra bridgeman, a gasoline four-wheel inspection car offers the best method of getting over the road, provided the traffic is not so dense as to make this dangerous.

For general inspection trips, a special inspection engine or train is usually provided. On some roads, where the towns are widely separated or hotel accommodations not desirable, this train is provided with commissary and sleeping quarters.

BRIDGE INSPECTOR'S TOOLS.—It is customary to prescribe certain tools and articles that a regular bridge inspector should always have with him, such as follows: Inspector's hammer, brace and bit or auger, testing bar,

*Abstract of report of committee of the Association of Railway Superintendents of Bridges and Buildings presented at Quebec, Canada, Oct. 20-23, 1903.

small axe, tape line, rule, callipers, and marking crayon.

BRIDGE INSPECTION REPORTS.—There are numerous existing bridge inspection systems and report forms which have proved serviceable under the special conditions and organization of road where used, but which could not be considered as sufficiently elastic for all conditions. In fact, your committee finds that the greatest difficulty it is confronted with is the attempt to outline one system for all conditions and roads. The committee presents the following outline of a system of bridge inspection reports as one that is applicable to general average conditions:

Current Inspection Reports for Maintenance: The current bridge inspection is made by a regular division bridge inspector (on some roads called "bridge walker") or by the master carpenter, foreman of bridges, or gang foreman. The purpose of this inspection is to examine the condition of the bridge and to determine any repairs required either in the near future or emergency repairs calling for immediate action. In all cases a record should be made while at the bridge of the conditions found and date of inspection.

There are several good forms in use for reporting the current inspection, as above explained, but the committee presents the following suggestions as offering noteworthy features, especially on account of the elasticity and adaptability of the forms to varying conditions and hence suitable for general recommendation and adoption.

A system much used is for the field record to be kept in a blank book and the notes are subsequently compiled and reported in condensed form.

Another system is to have special forms. The committee presents two recommended forms: Form "A," "Current Bridge Inspection Report," and form "B," "Summary Current Bridge Inspection Report."

Form "A," or the "Current Bridge Inspection Report," to be issued as a separate sheet, size 5¼ × 8 ins., or a book 5½ × 8½ ins., if desired to have it bound in book form. The horizontal ruling, if used, should be spaced ½-in. The blank is simple and allows the inspector in filling it out to use his own phraseology, and thus makes it elastic and adaptable to all classes of bridges, track openings, and structures for which such reports are prescribed. The blank can be either in pad form or book form. The inspector would either write out a copy for his record or use carbon paper and retain the duplicate. Instructions to bridge inspectors are issued by circulars or printed in each book. The inspector notes on the report any material needed for necessary repairs and also furnishes a sketch and dimensions of any special parts required. This form can be readily adapted and its size changed so as to be used in book form with a stub for the bridge inspector's record. The committee presents this blank as a separate small sheet, leaving it to individual preferences to issue it in book form, with or without stub, but expresses the opinion that the small sheets in pad form are preferable.

Recommended Form "A." Size, 5¼ × 8 ins.

Form M. W. Report No.

A. B. & C. R. R. Division

CURRENT BRIDGE INSPECTION REPORT.

I have to-day inspected

at

and find its condition as follows:

The following work is required to maintain structure in good condition:

The following work must be done to keep the structure safe:

Date,.....190 .....
Inspector.

NOTE.—Make separate report for each bridge or structure inspected. Send report daily to the..... of the Division Report by telegraph to the..... and the Superintendent of the Division all serious defects that require immediate attention.

In case the condition of the structure is dangerous, flag all trains and telegraph the Division Superintendent.

The purpose of form "A" is to force the inspector, whoever he may be, to record the fact that the bridge had been visited on a certain day and an inspection made and serves as a record and also advice to his superior.

Form "B," or the "Summary Current Inspection Report," to be issued as a separate sheet, 8 × 13 ins. The horizontal ruling should be ⅛-in. In case the reports are to be typewritten, horizontal ruling should be omitted. Where this report is to be used in field for recording the inspection while on the ground, it can be issued in book form and the size of the sheet reduced or made to cover two pages facing each other. The committee presents this blank as a separate sheet, leaving it to each railroad to issue same in modified shape in book form, provided it is to be used in the field. In case, however, the system of "Current Bridge Inspection Reports" is adopted and used for the field current inspection, then this "Summary Current Bridge Inspection Report" becomes an office blank and hence should be properly in sheet form.

The purpose of this form "B," when used only as an office form, is to summarize the daily or trip inspections during the month and make a condensed record of same. If used as the original field record it would be the only blank required for current inspection.

In the opinion of the committee, these two forms, either "A" and "B" combined, or using "B" only, offer a general and elastic system for the regular routine "Current Inspection," serving mainly to keep the bridges safe as far as ordinary maintenance by the division forces is concerned and at the same time enabling the superior officers to be advised of what is being done and recording all inspections or visits to bridges by parties responsible for the current maintenance work.

GENERAL BRIDGE INSPECTION REPORTS FOR GENERAL INSPECTORS.—As indicated above, the purpose for which a general inspection is made is of such importance as to warrant a more complete inspection report than absolutely necessary for current inspections.

A great many roads of the country have very elaborate and detail inspection reports for this purpose, some in sheets as large as four square feet in size, others in sheets of usual legal cap size, others in small or large book form, others in large books or sheets, one half of each sheet being virtually a copy of the "Bridge Record Book," and finally the method of using individual blank books for field memoranda (using the "Bridge Record Book" or blue prints of the "Office Bridge Records" for reference as to information about the bridges) and subsequently in the office compiling the information on large inspection reports.

Most of the forms specify in detail, by vertical column or side headings, the various items to be investigated at each bridge, in some cases as high as fifty items. While on particular roads and under certain organization systems this method of minute detail in the inspection reports may be working successfully, the committee does not believe that, in selecting a blank as adapted for general use by all railroads of the country, it should lose sight of the fact that there are many railroads that would not approve this great detail nor would they have the organization which would enable it to be carried through. To fill out these blanks conscientiously while on the ground would make the inspection cover too much time and there are roads reporting such blanks as nominally standard, but yet the system is not rigidly carried out from year to year.

It is impossible to prescribe in one form headings and items to be examined which are all adapted to all classes of bridges, trestles, waterways, track openings, highway bridges, etc., and hence in practice only part of the items can be filled in for any particular structure and frequently special items have to be added for which usually too little space is allowed. It would seem preferable to issue instructions and rules for inspecting the various classes of structures and leave it to the inspector to apply these rules in each particular case, mentioning in the report the general condition and noting specially where defects are found.

For the reasons indicated, especially also as the committee's endorsement of a blank should be such as to allow of its adoption generally, the committee believes that the general inspection report should be simple and elastic, so as to accommodate itself to any class of organization on a road and be adapted to the various classes of structures to be inspected without having on the one hand to omit filling out many of the columns or on the other hand having to add numerous items. In other words, the form should be more general, leaving it to the inspecting engineer to fill it out to such extent as thought desirable. Further, it should not be necessary to transcribe from the "Bridge Record Book" complete data as to the physical characteristics of the structure, as the transcribing of this data is unnecessary if the inspecting engineer has a copy of the bridge record with him for reference. It is desirable, however, for ready reference, especially of the highr officers who are not familiar with the various types of structures, to note briefly the principal characteristics, such as kind of bridge, length, age, and any pertinent reference to previous reconstruction or recent work done. The main feature in such a form is not to have it circumscribed by too much specialization and minutiæ in the column or side headings, but to leave ample space and opportunity to vary the wording of the record in accord with the various conditions and classes of structures to be embraced in the one report. Such a report will allow all classes of memoranda to be made according to the exact scope and special purpose for which it is made.

Recommended Form "B" Size 8" × 13"

Form M W

A. B. & C. R. R. ..... Division

SUMMARY CURRENT BRIDGE INSPECTION REPORT

For 190

Bridge No. or Structure	Kind of Structure	Day of Month Inspected	Condition	Action Taken or Recommendation

Date.....190 .....

NOTE—This report to include all bridges and structures inspected during the period covered by the report.

The committee recommends the adoption of form "C" to be known as "General Bridge Inspection Report," to be issued in book form and in separate sheets. In book form for field use, each page would be 5½ × 8 ins., with sheets, 11 × 8 ins., folded in the middle, making a book 6 × 8½ ins. The separate sheets for office use and summary reports, should be exactly the same as used in book, viz.: 11 ins. wide and 8 ins. high, printed on one side only. If desired, however, special blanks of larger size for office use could be printed. The horizontal ruling should be ⅛-in. The separate sheets for office summary reports should be left without horizontal ruling if typewriter is to be used.

CONCLUSIONS.—There should be a clear distinction made between "Current Inspection" and "General Inspection."

The purpose of the current inspection is to keep the structure in safe condition, to promptly discover any defects, and to report same promptly so that repairs can be made before the safety of the structure is affected. It is important that a simple record should be made while at the bridge and the superior officer kept advised of all such inspections promptly, whether made by a bridge mechanic, gang foreman, or division bridge inspector.

The purpose of the general inspection, frequently called the annual inspection, although in many cases conducted semi-annually, or even quarterly, is not only to check the maintenance work of the division organization, but to make a more careful investigation of important bridges, to make suitable record of the general condition of all bridges and structures on the entire road, and further to ascertain and settle what extensive special repair or renewal work should be done in the following working season.

The current inspection should not be done in a haphazard or intermittent manner, but should devolve on one or more experienced and trained bridgemen whose duty it should be to follow up the current bridge inspection along a certain prescribed programme which would vary according to the local conditions on each road. The division engineer or superintendent of bridges and buildings or whoever has general charge of bridge maintenance on the division or district, should watch the current bridge inspection reports and act promptly on receipt of same, according to the emergency. He will necessarily, in important cases, make a personal supplementary examination and must keep himself advised at all times of the general condition of all bridges and structures under his control by frequent inspection trips over his territory.

For recording the current inspection, the committee desires to emphasize that there are many good and valuable systems and forms in use adapted to special conditions on many railroads, but believes its recommendations should cover only forms which are elastic and adapted for general conditions.

The committee recommends for recording the current inspection either a blank book, supplemented by typewritten reports, or the forms "A" and "B" presented with this report and known as the "Current Bridge Inspection Report" and the "Summary Current Bridge Inspection Report."

For use of the general inspection the committee recommends the form "C," presented herewith and known as the "General Bridge Inspection Report."

Your committee further recommends that the regular

bridge department should be responsible for and hence should inspect and report on all bridges, culverts, masonry, and foundations, without placing direct responsibility on the track department. This, however, should not exclude the track department from watching all such structures in a general way and the obligation to report promptly any unusual signs of defects or trouble, and to take such necessary steps as the emergency may require, more particularly in connection with the waterway opening, condition immediately after high water, burnouts, damage done by accidents or casualties of any kind, etc. The track department should be responsible, however, for keeping waterways clear, bridge seats clean, extinguishing fires, keeping small drains open, and the track in proper shape at the runoff at each end of a bridge and on the bridge, using when necessary temporary shims on the bridge ties.

Walter G. Berg, Chairman; J. A. Dodson, C. F. Loweth, Arthur Montzheimer, A. Zimmerman, A. Shane, I. O. Walker, Committee.

Recommended Form "C" Size 11"×8"

Form M.W.
A.B. & C. R. R.
.....Division
From.....To.....

GENERAL BRIDGE INSPECTION REPORT
For.....
Inspected by.....190

Bridge No. or Structure	Location	Kind of Structure	Bridge Data	Date Inspected	General Condition, Description of work required, Recommendations.

ANNUAL CONVENTION OF THE ASSOCIATION OF RAILWAY SUPERINTENDENTS OF BRIDGES AND BUILDINGS.

The 13th annual convention of the Association of Railway Superintendents of Bridges and Buildings was held at Quebec, Canada, on Oct. 20 to 23, inclusive. The headquarters and place of meeting were the Chateau Frontenac, and during the convention about 125 members and guests were registered. The meeting was one of the most successful in the history of the Association. The committee reports were satisfactory and their discussion thorough, and the meeting place was one of the most delightful perhaps in America. The work of the convention was divided into seven sessions, but in this account of the meeting no attention will be paid to these, and the proceedings will be given in order without regard to time

The members of the convention were welcomed to Quebec by a representative of the Mayor, whose speech was replied to on behalf of the Association by Mr. R. H. Reid (L. S. & M. S.). The convention was then addressed formally by the President, B. F. Pickering (B. & M.), and afterward proceeded to routine business, which occupied the whole of the first session. The report of the Secretary showed the following receipts and expenditures for the year:

Receipts	$1,695
Expenditures	1,504
Balance	$191
Balance brought forward	719
Total balance on hand	$910

The membership of the Association is 183, not including new members elected at this convention. These new members number 60, and constitute the largest increase in membership for any year since the second of the Association's organization.

The election of officers for the ensuing year resulted as follows: President, Arthur Montzheimer; First Vice-President, A. Shane; Second Vice-President, C. A. Lichty; Third Vice-President, J. B. Sheldon; Fourth Vice-President, J. H. Markley; Secretary, S. F. Patterson; Treasurer, C. P. Austin; Executive Members,, R. H. Reid, W. O. Eggleston, A. E. Killam, R. C. Sattley, H. Rittenhouse, J. S. Lemmond.

COMMITTEE REPORTS AND DISCUSSIONS

The first committee report to be taken up was that on Falseworks for Rock Bottom and Rapid Current. This report and the discussion which followed will be published in a future issue.

SHOULD CAMBER OF BRIDGES BE REMOVED?—Mr. R. H. Reid (L. S. & M. S.), the Chairman of this Committee, presented the following individual report:

I find that nine members prefer a straight deck on bridges, taking out all camber; three take out half the camber; one member who has wooden lattice trusses, with about 2½ ins. camber in them, leaves one-half the camber in; eleven leave in enough camber to bring the bridge level under a full load; three members leave all the camber in iron bridges; two take out the excessive camber in the stringers, where wooden stringers are used; one recommends taking out all camber in ordinary plate girders, but leaving the camber in in long and shallow plate girders, where the deflection is noticeable; one leaves the camber in for ordinary plate girders, on the assumption that the camber framed in these spans is so small as not to be noticeable; two prefer a straight deck over piers where there is more than one span; one leaves about one-half camber where there are several spans of 150 ft. or less; three members design bridges so that the excessive camber can be taken out in the floor system. This, in a general way, covers the range of information received.

The committee would recommend that in all new truss bridges enough camber should be provided to bring all joints to a full bearing when the structure is fully loaded, and take out the excessive camber in the framing of the floor system, leaving enough camber in the tracks so that the bridge will come down level under a full load. Under something less than a full load, the track will still have a slight crown to it, which is less objectionable than a sag would be under a maximum load. Ordinary plate girders under 60 ft. long should be designed without camber. Over 60 ft. long the camber should be equal to the deflection of the girder under a full load. Plate girders of special proportions should be designed for each special case, as no uniform rule would apply to all proportions of girders. Wooden truss bridges, of course, would require more camber than iron bridges, but the same rule would apply to them as to the iron truss bridges.

The discussion on this report consisted of a relation of practice of the various members, and very little information was brought out that was in any way new. As a general thing it is the practice to remove the whole or a part of the camber by gaining the ties.

REPAIRING SWING BRIDGE WITH WRECKED ARM.—This committee was appointed to consider the following question. In case one arm of an important metal swing bridge over a deep stream should be wrecked, what is the most expeditious way to restore railway and water traffic? The committee outlined six possible methods of performing the work which may be defined briefly as follows: (1) Replace the damaged arm by trestle and swing the intact arm by carrying its free end on a pontoon. (2) Replace damaged arm by trestle and swing intact arm in regular way after counterweighting back of pivot. (3) Replace damaged arm by temporary wooden swing span and use intact arm as fixed span. (4) Rebuild damaged arm. (5) Leave intact arm in place and replace damaged arm by staging carried on pontoons which can be hauled away for passage of vessels. (6) Leave intact arm in place and replace damaged arm by temporary span on pontoons.

This report received very little discussion, the accident being so unusual that few members had had any experience with such work.

PROTECTING SOLID BRIDGE FLOORS.—This report was made up of replies, sent to a circular of inquiry sent out by the committee, and from these the following were of the most general interest:

Mr. A. F. Robinson, Bridge Engineer, A.,T. & S.F. Ry.: For solid floors in bridges we use transverse I-beams spaced from 12 to 20 ins. apart centers, and resting upon the bottom flanges of the girders of stringers, or upon shelf angles riveted to the same. On top of these I-beams there is a course of creosoted timber from 2 to 5 ins. in thickness and above this the course of ballast. Where we are using deck girders with a ballasted floor, we have covered girders solid with a course of creosoted timber, the thickness varying to suit the space between the girders, and top the same out with the regular course of ballast. In both of the above schemes the metal work is left entirely uncovered so that all parts can be examined and can be cleaned and painted by the ordinary methods.

We have one bridge, a 90-ft. girder span, in which the I-beams are topped out by a steel deck plate and the rails are fastened to the running plate which rests on top of the deck plate without the use of ties. We have found no method by which we can with certainty protect this kind of floor from the effects of rust. It is also extremely noisy under traffic, and in Chicago floors of this character will become such an intolerable nuisance that the city will force the railroad companies to cover the same with ballast. In Chicago where a large percentage of track elevation bridges have been made in the above manner, the deck plates have been covered with a gravel tar roofing protection. I have noticed that these floors do not leak for perhaps an hour after the rain storm begins, but that they are continually dripping water for several days after the storm. In many cases where I have cut into this gravel tar roofing, I have found water or moisture on top of the deck plate underneath the roofing, and the deck plate has always been very rusty. I do not believe we will ever find a method by which we can protect a deck of this character.

We have no trough floor bridges on the line. The only solid floor structures are as above noted, made with I-beams which are covered with creosoted timbers resting directly upon the tops of the girders. Where we are obliged to give a water-tight floor, the clear head room for street underneath is fixed at center of street crossing. One end of the bridge is then tipped up and the other down sufficiently to make the timber floor drain from one end to the other, the tracks being laid to grade, the ballast being deeper at one end of the bridge than at the other. Where we have to make a water-tight floor the material is tongued and grooved and the seams are caulked with oakum or with cotton and filled with calker's pitch. After calking the top of the floor is covered with one heavy coat of hot cold tar.

Mr. Benjamin Douglass, Bridge Engineer of the Michigan Central R. R.: We use I-beams with plate on top and riveted to them. Ballast supported directly by the plate and plate by the beams. We have never used anything but paint to protect the underside of steel floors. If they are exposed to much gas, something better should be used, but just what I do not know. There is one question which you will probably like to have answered which was not included in your list and that is the method of protecting the floor plate under the ballast. In the type of floor we use, our method is to heat the floor either by means of fire suspended underneath, or by the flame of a torch applied in top. When the floor plate is quite hot, we pour on melted asphalt and form a coating nearly or quite ¼-in. in thickness, applied as two coats. This has so far proven very satisfactory. The first bridge of this type which we put in was moved to another location last year, and after the ballast had been removed, the coating was found in perfect condition and the plate underneath absolutely free from rust except a little scale such as is on all material when first erected.

Mr. H. Fernstrom, Chief Engineer, N. Y. C. & H. R. R.: We either use a solid trough floor, consisting generally of vertical web plates, horizontal top and bottom plates and angle iron at corners for riveting the same together, or we build solid floors of I-beam sections with a solid plate on top, which we generally make 7-16 in. thick. The latter construction is to be preferred. We line trough sections with an asphaltum composition, and the bottom with an asphaltum concrete (asphaltum and gravel mixed), shaped to the bottom of the trough so as to give drainage. The layer varies in thickness at the bottom of the trough from 1½ to 3 ins. At the lowest point where this layer would be about 1½ ins. thick, gas-pipe drainage nipples are placed in the bottom of the trough passing through the same; the gas pipe being threaded and screwed into the bottom trough plate. The ballast side of steel floor is first painted with red lead and then given a coat of refined asphaltum and straight run coal tar pitch heated to a temperature of 300° F., and mixed 10 parts of the former to 30 parts of the latter. The underside of solid floors is painted the same as the other steel work—two coats of red lead and two coats of New York Central asphaltum varnish. We have in one case, where the structure would come very close to the smokestack of passing locomotives, suspended a shield made of expanded metal lath plastered with cement mortar. This has been in service about three years and has been fairly successful. An I-beam and steel plate solid floor is the best solid floor construction, but would not recommend fastening the rails directly to this steel floor; prefer to have the rails on ties and ballast under same. Our experience is that this ballast on the solid floor bridges practically takes up all impact from the drivers of engines and thus reduces the live-load stresses far more than the increase in stresses caused by the weight of the ballast.

The discussion on this report was quite extensive and turned principally upon the insufficiency of any of the commonly used methods of protection to do good work for any length of time.

SANITARY ARRANGEMENTS AT SMALL STATIONS.—This report was very brief, and gave very little information on the subject. In the discussion which followed attention was confined almost entirely to the construction and care of station closets. The general practice as shown by the discussion was to build tight vault earth closets, ventilate them by a flue from vault to roof or outside wall, and to depend upon this construction and upon care and frequent cleaning to keep the closets inoffensive.

BRIDGE INSPECTION.—This committee made a very complete report, which is published in abstract in another column of this issue. The discussion was long, and consisted of a statement of the practice followed by the various members. This practice varied only in details and differed but little from that outlined in the report.

PURIFYING WATER FOR ENGINE USE.—This report was made up almost entirely of the paper by Mr. G. M. Davidson, Engineer of Tests, Chicago & Northwestern R. R., which was read before the Western Railway Club, and is already familiar to our readers. There was no discussion of importance

STORING FUEL OIL.—This report covered a new subject, which has come to be of interest within the last few years, and it is given in abstract as follows:

In planning a fuel oil station there should be provided a track on which to receive the tank cars in which the supply of oil is brought; a storage tank of sufficient capacity; a delivery tank and stand-pipe for supplying the locomotives and a pump or other means for transferring the oil from the cars to the storage and delivery tanks.

In unloading oil from the cars there are three methods in use: (1) By simply opening the valves under the cars and letting the oil run into a trough, located between the rails, from which the oil flows into a vat or sump, and

from it again, it is pumped into the storage and delivery tanks. (2) By the use of compressed air to unload direct from the cars into the tanks. (3) By connecting the tank cars to a line of pipe alongside of the track which, in turn, is connected direct to the pump and the storage tanks so that the oil is pumped by steam direct into the tanks. Where this plan is followed one boiler can serve both the water and oil pumps, and one man can attend to both pumps.

Storage tanks run from 5,000 to 55,000 barrels capacity, according to the necessities of the case. In locating them at or near a town, it must be borne in mind that, owing to the inflammable nature of the oil, opposition is apt to be met with from the authorities. When the location is finally decided upon the ground should be brought to a level and the tank laid on the earth without any further foundation, provided, of course, that the ground is of such character that it will support the weight without settling more than a few inches. Sometimes the ground is first saturated with oil before erecting the tank, we can not say, however, if there is any merit in the practice. The tank or tanks should be surrounded with an embankment, high enough and far enough away, so that the space enclosed will be more than sufficient to hold all of the oil stored in the tanks when full, in order to guard against the failure of the tank or the oil taking fire. In building the surrounding embankment the earth should not be taken from the inside unless the borrow pits can be thoroughly drained. If water stands in the borrow pits, more or less oil floats on top of it, and is in constant danger of taking fire.

Where is it permissible to elevate the tank above the rails, an ordinary water-tank, elevated high enough to give the proper head, will answer all purposes. It should also be surrounded by an embankment for safety's sake. Where it is not possible to elevate, we recommend the Southern Pacific Company's delivery tank plan, which is partly buried to satisfy both municipal ordinances and insurance regulations.

The use of compressed air for handling oil entails no great extra expense at shops and terminals where plants have already been installed for testing cars and driving shop tools. In the plan of the delivery tank of the A., T. & S. F. Ry. Co., provision for heating the oil in cold weather, is made by a steam coil inside the tank near the discharge valve.

Owing to the explosive character of the gas given off by fuel oil firemen and other employees are forbidden to go near the opening of the tender tank with lights of any kind. To guard against carelessness on their part a head light should be mounted on a post alongside the track at each point where locomotives are supplied, and so arranged that it can be trained from below by ropes on the manhole in the tender tank.

When the water and fuel oil stations are at the same point either a double or two separate oil stand-pipes should be erected with a spout on either side of the water spout or vice versa so that water and oil can be delivered with only one stop of the locomotive.

THE KANSAS CITY FLOW-LINE BRIDGE REPAIRS.

By J. A. L. Waddell, M. Am. Soc. C. E.*

Because of numerous requests from engineers and others, the writer has been induced to prepare the following statement concerning the repair work to the bridge over the Kaw River that carries the pipes for the water supply of Kansas City, one span of which structure was destroyed, and the other badly injured, by the great flood of May 31, 1903.†

The bridge, which is located a very short distance from the river's mouth, consisted of two steel Pratt-truss spans of a rather antiquated type (the floor beams being suspended), resting on two masonry abutments and one cylinder pier. The abutments were not used for retaining earth, probably because they were of insufficient stability. The center pier, however, was well built, and consisted of two 7-ft. iron cylinders sunk to and into the bed rock by the pneumatic process, well sway-braced, and filled with concrete. The span that went out was 185 ft. long and the one that remained was 226 ft. The upstream truss of the latter was crippled in three vertical posts near mid-span and in the bottom chord, and the floor beams, hangers, and sway bracing were pretty badly wrecked, rendering the span so unsafe that it was liable to fall at any time.

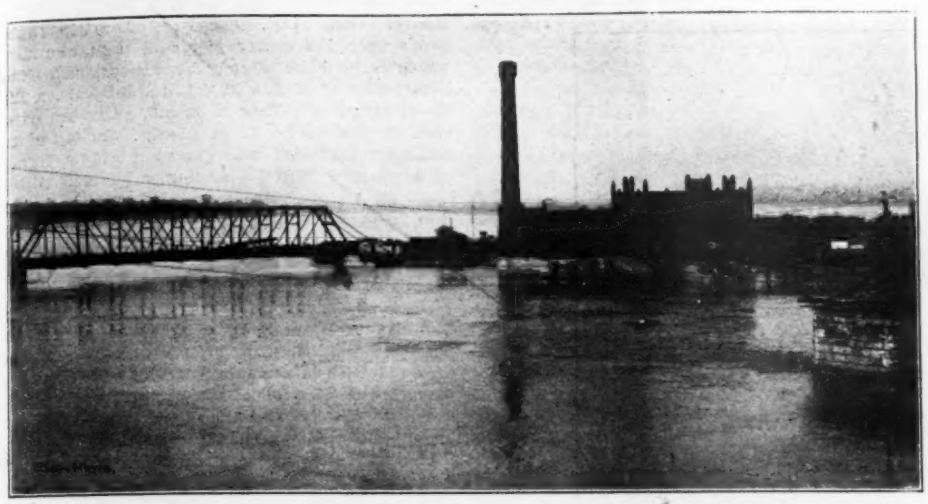


FIG. 1. VIEW OF STANDING SPAN OF FLOW LINE BRIDGE AT KANSAS CITY ONE WEEK AFTER FLOOD OF MAY 31.

The accompanying photograph, Fig. 1, although on a very small scale, shows quite clearly the condition of the posts of the upstream truss. This picture was taken nearly a week after the bridge was wrecked and after the water had subsided several feet. During the extreme height of the flood the water came up to the cross-girders, but did not quite reach the bottom chords. It was an accumulation of driftwood (a lodged portion of which appears in the photograph) that did the damage.

The shorter of the two spans was carried away about six o'clock on Sunday evening, and news of the disaster did not reach the writer, who was at Chicago, until the next day. He took the first train for home that evening, but because of numerous washouts did not arrive there until six o'clock on Wednesday morning. Mr. Ira G. Hedrick, the writer's partner, happened to be spending Sunday in Kansas City, Kan., opposite the city of Kansas City, Mo., and from that point he saw the Flow Line bridge and a number of the other Kaw River bridges carried down by the flood. In spite of his proximity and of his using every endeavor to reach the office, he failed to do so until a few hours after the writer's arrival, mainly because of the rapid current in the Kaw and Missouri Rivers.

From the time of the disaster until this writer's arrival, Mayor Reed, of Kansas City, was making numerous endeavors to communicate with the members of the firm of Waddell & Hedrick, to whom he turned for assistance in his hour of need. The crisis was most serious: the water supply of the city was almost entirely shut off, the small amount of water that for a short time was pumped from the Kaw River being so seriously contaminated that it was condemned by the City Chemist as absolutely poisonous. The entire city, too, was at the mercy of the fire fiends; and had it not been for the numerous and thorough precautions taken by Mayor Reed and his officers, Kansas City would have been given over to the flames. Again, owing to the failure of the water supply, the street cars stopped running; the sewers fouled for want of flushing; the general use of water closets throughout the city had to be abandoned; the gas supply for a time was stopped; and the electric light plant was placed *hors de combat*.

The entire city was truly in a bad plight, threatened as it was with fire, pestilence, robbery and drought; so there was no time to lose. All depended upon the quick repairing of the broken pipe line and the replacing of its supporting bridge.

At 10 a. m., on June 3, the writer met the Mayor and received from him instructions to prepare a plan to build, regardless of expense and in the shortest possible time, some kind of a structure which would carry safely the pipe and its load of water, and thus relieve the dire need of the city.

Upon consultation with Mr. W. G. Goodwin, Superintendent of the water-works, the writer found that he and his assistants were debating whether it would be better to build a pontoon or a suspension bridge, a pile structure being deemed out of the question. The writer decided at once against a pontoon bridge, because of the danger from drift and the trouble which would be encountered from rising and falling water, and pronounced in favor of a suspension bridge.

During the forenoon arrangements were made for the use of a large steamer for the purpose of visiting the wreck and determining the conditions; so shortly after noon Mr. Hedrick, Mr. Robert W. Waddell, ex-City Engineer, the writer, and a number of others made the trip.

FIG. 2. SUSPENSION SPAN OF FLOW LINE BRIDGE.

Although the water had fallen considerably, it was still almost up to the floor of the remaining span, and the current was so swift that the steamer was unable to make any headway against it. It might have been practicable to reach the structure by floating down against it in a small boat, but the risk involved would have been great,

*Waddell & Hedrick, Consulting Engineers, Kansas City, Mo.

†A description of the flood, written by Mr. Waddell, was published in Engineering News of Sept. 17.

so it was not attempted. Moreover, barring the actual condition of the remaining span, all the information required for rebuilding the bridge upon the suspension-span basis was already collected.

One anchorage was located upon the high ground in the street on the west bank, and the other adjacent to a railroad embankment, which

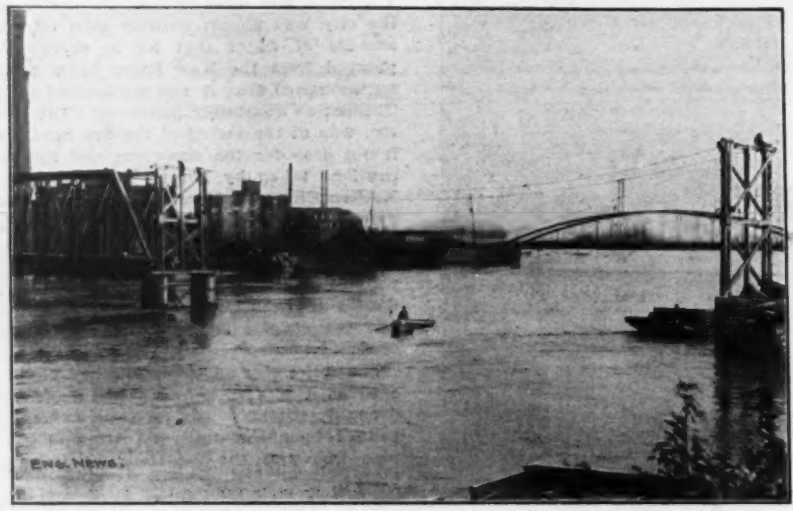


FIG. 3. VIEW SHOWING TIMBER BENTS ERECTED FOR FLOW LINE SUSPENSION SPAN. (SPAN OF JAMES ST. BRIDGE IN BACK GROUND.)

formed the approach to what had been the Chicago Great-Western bridge. As the river was almost at the level of the top of this bank, it was necessary to construct the anchorage in the water, running the back stays through the embankment close to the rails. These back stays were to be carried from the center pier along the top chords of the remaining span, being supported over the pier and east abutment by timber bents. One of these was required also over the west abutment.

By carrying the cables along the top chords and by making the timber bents of the same height as its trusses, the crippled span was not called upon to sustain any stress from the suspension span (as had at first been contemplated by the waterworks officials), excepting only that it would have to support a small portion of the weight of the cables lying thereon. In view of the dangerous appearance of the span it was deemed necessary to avoid so far as possible placing any additional load upon it.

We returned to the office about four o'clock and immediately the designing was started, while the telephone was utilized in searching for materials. At this time Kansas City was practically cut off from the outside world as far as freight transportation was concerned; consequently, it was necessary for us to procure all the materials for the bridge from local dealers. Already for two or three days there had been a large demand for timber to be used in various kinds of repair work, and we were therefore unable to procure the large timbers we needed and were forced to figure on building many of them out of planks.

For main cables we were compelled to adopt some second-hand 1½-in. wire ropes, belonging to the Metropolitan Street Ry. Co. These had been used by their cable roads as long as it was deemed safe to employ them and then stored away as refuse. It was figured that they still retained one-half of their original strength, or 50,000 lbs.; and we aimed to strain them about one-third of that amount.

As for suspenders, we found a supply of new ½-in. wire rope, said to have an ultimate strength of four tons. This we decided to use with a factor of safety of about four. Unfortunately, as we learned later on, a mistake had been made concerning the strength of this rope, which mistake nearly involved us in serious trouble.

For other metal the Riverside Iron Works Co. kindly put their stock and shops at our disposal.

An ample supply of Portland cement was obtainable, although great quantities of it had been ruined by the flood, most of the cement houses being located on the river bottoms. A supply of good sand was found close to the east end of the bridge, having been stored there by one of the railroad companies. This became available as the water level fell. Broken stone could be obtained in the city and barged to the site with the aid of steamers. Plant and tools were to be had from the local office of the American Bridge Co., and these were generously placed at our disposal.

Plenty of bridgemen and laborers were at hand, owing to the cessation of work caused by the floods.

We labored steadily on the computations and drawings until darkness overtook us; then we endeavored to turn on the electric light, but found that it was cut off because of the want of water to supply the boilers. The use of kerosene had been declared illegal, and what was more to the point, we had no lamps. At this hour all the stores were closed, so we were forced to beg candles from the Midland Hotel and to improvise candlesticks. With this insufficient light, by working until after midnight, we succeeded in finishing the pencil drawings and bills of materials.

Early next morning (June 4) our report to the Mayor was handed in, but as it had to be acted upon by the City Council, it was not until nearly 4 p. m. that we were empowered to go ahead. By 6 p. m. all the materials were ordered, and some of them were started by wagon to the temporary steamboat landing at the foot of the Fourth Street Viaduct; barges and boats were secured for transportation, and workmen were ordered to report early next morning at the site.

The services of Mr. Geo. H. Griffin, lately foreman for the American Bridge Co., were secured, and it was arranged that he was to provide and take charge of all the skilled laborers.

Early the next morning (June 5), under the direct supervision of Mr. Hedrick, work on the west anchorage was begun. By 7 a. m. wagons containing timber, cement and broken stone were lined up at the landing waiting for the barges. As soon as these appeared they were loaded, and the materials were transported to the site of the east anchorage, where a small amount of dry land on top of the embankment had begun to show itself above the water. On this the materials were stored, and by noon the construction of the cofferdam was begun by Mr. Hedrick, assisted by Mr. L. R. Ash, one of our engineers.

A small pile driver was quickly constructed and a cofferdam of two rows of sheet piling with clay between was built, concreting therein being started about midnight of the same day, as the pile driving was finished at 9 p. m.

By working continuously, the entire anchorage was completed at 1 p. m. on Saturday, June 6. Both Mr. Hedrick and Mr. Ash stayed on this work without rest from start to finish.

Meanwhile the construction of the west anchorage was being continued under the direction of Mr. B. H. Cochrane, our Chief Draftsman, and Mr. C. K. Allen, a former employe of our firm, but at that time in the employ of the City Water-Works, his services having been lent us on this special occasion. This west anchorage was completed at 7 a. m. on Saturday, June 6.

Before proceeding farther with the history of the construction, it will be well to describe the structure that was building.

The new span consisted of eight of the second-hand steel cables, four per side, having a deflection of about 24 ft. These rested on the timber bents over the center pier and west abutment, which bents have already been mentioned. Each bent consisted of five 12 × 12-in. verticals, a 12 × 12-in. cap, and a 12 × 12-in. sill, sway-braced on both sides with 4 × 12-in. planks. On top of the cap near each end was placed a saddle formed of a rounded 12 × 12-in. timber covered with a ½-in. steel plate. The suspended span is divided into 20 panels of 9 ft. 3 ins. each, the suspender cables being wrapped around the main cables and having their ends secured by three standard clamps each.

These suspenders attach at their lower ends by thimbles to beam hangers that run at a slight angle to the vertical through the floor beams, each of which is a single 8 × 8-in. × 16-ft. yellow pine timber. On top of the beams run longitudinal floor planks, and these are swayed beneath by crossed planks spiked thereto.

The stiffening trusses, which are spaced 9 ft. 6 ins. c. to c., are 6 ft. deep between centers of chords. They are built entirely of 2 × 12-in. planks, excepting that the verticals are of 4 × 6-in. timber. The top chords are side-braced to the floor beams, it having been originally the intention to adopt pony trusses, but after the pipes were laid, as a matter of precaution and to obtain additional lateral rigidity, an overhead system of horizontal sway-bracing was added. The pipes rest on shims of 8 × 8-in. timbers, placed directly over the floor beams.

The accompanying drawings, copied from our hastily prepared and rather crude working drawings, illustrate the features of the bridge which have just been described. It is to be noted, however, that the plan shows an additional pipe carried by the structure and the strengthening of the latter for same, of which more anon. The accompanying photograph, Fig. 2, shows the finished bridge, and illustrates quite clearly most of the features and details mentioned.

As can be seen on the drawings, the main cables pass around a 6-in. car axle that rests against four 12 × 12-in. timbers, all embedded in the concrete, and are then carried outside of the anchorage, where they are connected by standard clips.

The timber bents over the pier and the east abutment are stayed to the portals of the old span

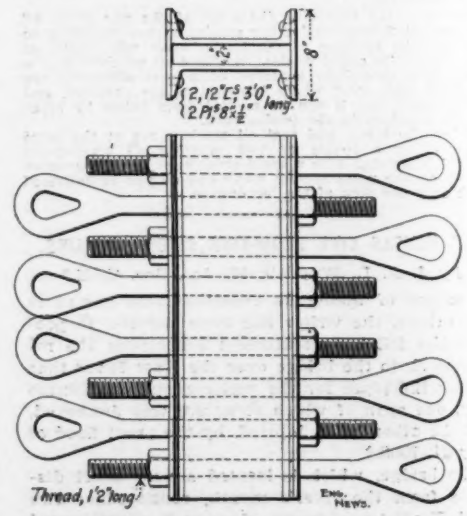


Fig. 5. Details of Adjuster for Main Cables.

by timbers well bolted at each end. This bracing gave us a little trouble when adjusting the cables, but it was overcome without much difficulty.

The material for the bents was framed on Friday night, June 5, and Saturday forenoon. It was necessary to build most of the large 12 x 12-in. timbers of 2 × 12-in. planks, well spiked together. The timbers for the stiffening trusses were framed

on Saturday during the night. By Sunday morning, June 6, the bents were erected, and during that day the cables were unloaded and inserted into the west anchorage. By sundown one cable had been carried across, and during the night three more cables were put in place. One of them, unfortunately, had been cut too short, so it was necessary to splice it. To do this, we sent a man out in a tub with a lantern. His position appeared precarious in the extreme, suspended as he was in the darkness over the raging flood; but he managed to make the splice without coming to grief.

This is not the only piece of bad luck that we had that night, for about 9 p. m. the remaining span of the James St. bridge, which was situated a short distance upstream from our work, went out with a loud crash and a roar of water, frightening the workmen to such an extent as to cause a stampede for the shore. In truth there was some danger to our bridge, as the floating floor system came perilously close to the deck of the old span, but luckily it passed without lodging. It was some time, however, before the men got over their fright and could be induced to resume work.

The accompanying photograph, Fig. 3, shows the span that went out. It was taken only a few hours before the final accident occurred. This was caused by the undermining and partial wrecking (during the flood) of the east abutment on which it rested. The proximity of this span to our work is shown clearly in the picture.

On Monday forenoon, June 7, the remaining main cables were strung, and before midnight they were all adjusted to practically the same tension.

Up to this time Mr. Hedrick had been working day and night almost without any sleep, lying down occasionally on the soft side of a plank for forty winks, while the writer had been engaged mainly in forwarding materials, procuring food for the workmen, and, incidentally, attending to office correspondence. For this night it was arranged that Mr. Hedrick should leave the work early so as to obtain a full night's sleep, and that the writer should take charge about ten o'clock, one of our assistants looking after the work meanwhile. As luck would have it, the man running the naphtha launch, which was to have met the writer at the landing, failed to put in an appearance, so after waiting an hour for him, and there being no other way to reach the bridge, the writer requested the captain of our steamer to take him there. This steamer was then on its way to pull off another steamer stranded near the mouth of the Kaw, a job that was expected to take only a few minutes. The result of the attempt, however, was to place our steamer in the same predicament; consequently, the writer was forced to spend the night out on the river and was not able to get away until daylight, when he hailed a small boat that was passing.

During the previous day a large force of men had been at work on the old span, putting in temporary wooden stringers and repairing the floor so as to make it strong enough to carry the pipes and their load of water, but nothing had been done as yet to strengthen the crippled upstream truss. We recognized that there was danger involved by this omission, but there were so many other things to be done all at once that we took the chance, keeping an eye on the bent posts so as to make sure that they buckled no further.

This floor repair work was continued after dark by means of the torches with which, from the outset, the work had been liberally supplied. About one o'clock in the morning the foreman in charge made up his mind that the injured posts were falling, so he called his men off the bridge, and in consequence no work was done during the remaining hours of darkness.

Upon the writer's arrival soon after daybreak on Tuesday, June 8, he interviewed the men and found that they were all afraid to go again upon the crippled span. By offering double pay until it was strengthened and by pointing out that the engineers would remain upon it until the posts were reinforced, a few of the men were induced to resume work, but many of them held off until after the wooden posts were in place.

The first thing to do was to relieve the largest and most injured of the three bent verticals by placing alongside two timbers bearing at top on a timber shim inserted beneath the upper chord and at bottom on a similar shim resting on the chord bars. What the bending effect induced on the latter amounted to we did not stop to figure, for our judgment satisfied us that the bars would stand the extra strain, notwithstanding the fact that they were bent considerably out of line.

During the day both the top and bottom chords were stayed by guy-ropes to the old water-works building, because the bottom chords had been bowed out of line by the drift, and the men were afraid that the span would fall by increased buckling. In the opinion of the engineers this staying was not necessary, but they did it to pacify the men and to induce them to resume work.

By sundown a working platform had been constructed and suspended from the cables at the west bent by means of ropes and pulleys. The small suspender cables with all the necessary tools for fastening them on were placed upon this platform, and then four workmen and an engineer got aboard and were pulled across the river from the other side, fastening the suspenders at the proper intervals as they went along. This task occupied the entire night, and at midnight a lunch was sent out to the men by means of a keg fastened to a rope "ferry" stretched across the opening. As fast as the suspender cables were fastened on, the cross-beams were hung at their lower ends, and early in the morning (Wednesday, June 10) planks were laid on the beams so

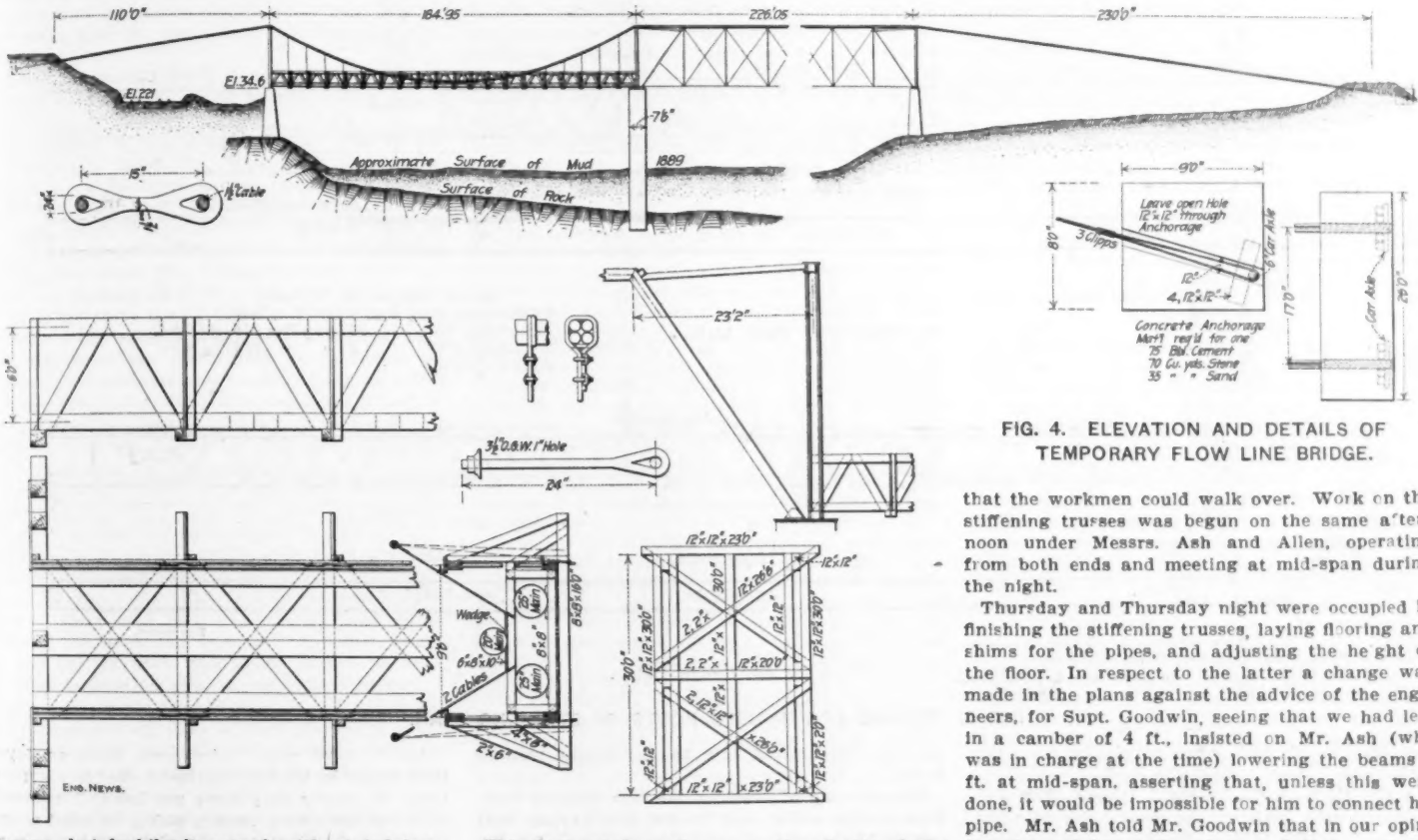


FIG. 4. ELEVATION AND DETAILS OF TEMPORARY FLOW LINE BRIDGE.

that the workmen could walk over. Work on the stiffening trusses was begun on the same afternoon under Messrs. Ash and Allen, operating from both ends and meeting at mid-span during the night.

Thursday and Thursday night were occupied in finishing the stiffening trusses, laying flooring and shims for the pipes, and adjusting the height of the floor. In respect to the latter a change was made in the plans against the advice of the engineers, for Supt. Goodwin, seeing that we had left in a camber of 4 ft., insisted on Mr. Ash (who was in charge at the time) lowering the beams 2 ft. at mid-span, asserting that, unless this were done, it would be impossible for him to connect his pipe. Mr. Ash told Mr. Goodwin that in our opinion the weight of the pipes and their contents would be sufficient to take out nearly all of the 4-ft. camber. Nothing would satisfy him, though, but lowering the floor, so that was done, the result being as shown in the accompanying photographs, a reverse camber of about 18 ins. This really does no harm, but it looks ugly. Of course, it is practicable to take up the sag by means of the adjustments in the main cables.

These adjustments, by the way, are of sufficient interest to warrant a description. The device, which was evolved by Mr. Hedrick, consists of a pair of heavy 15-in. channels placed back to back, with a space of 3 ins. between, through which pass short screw bolts having a nut at one end and an eye at the other for the attachment of the cable. These bolts act alternately in opposite directions, as shown on the accompanying sketch. This detail is both simple and effective.

While the suspender cables were being attached, their great pliability caused us to think that they had not the strength which we were counting upon, and this opinion was corroborated by the breaking of a piece of cable used on the work. By investigation we found that the dealer who supplied the cable had made a mistake in obtaining its strength from his tables, and had furnished us with rope of only one-half the capacity we had figured upon. In consequence of this discovery we arranged immediately to reinforce the suspenders, and, as we had experienced much diffi-

culty in distributing the loading equally thereon, as a matter of precaution, we decided, since we had an ample supply of the rope, to triple instead of double the suspenders.

Pipe laying was begun about 3 p. m. on Thursday, and early Friday morning, June 12, the pipes were all laid and connected, although the supporting shims were not all in and a number of the suspenders had not been strengthened.

Mr. Goodwin had been notified not to turn the water on until after we had told him all was ready, and he so instructed his assistants. However, one of them without consulting us, on learning that the pipe was connected, telephoned to Quindaro to turn on the water. The result was that three of the weak suspenders snapped with a loud report, and the breaking of the others and consequent destruction of the entire span appeared imminent. Fortunately, the strengthened suspenders had not been put in consecutively, but

our two naphtha launches, although under contract with the city, deserted us continually in order to earn large pay by ferrying passengers, and everybody was hustling us to get the job done and the water pipes filled.

The mental strain upon the engineers was intense, for all of us recognized that over one hundred million dollars' worth of property was in imminent danger from fire; that the health of a quarter of a million people was jeopardized by the drinking of cistern water and other impure waters, and by the accumulation of filth in the unflushed sewers, and that the life of every man on the work was in constant peril.

The engineers not only did the usual engineering work, but also were compelled to perform the functions of superintendents, foremen and contractors—they even at times labored with their own hands when workmen were not present in sufficient numbers, and whenever it was necessary

while going to still another livery stable, the writer met a one-horse wagon labelled "Water-Works," so he stopped it and ordered the driver to collect and carry the lunches to the landing. The fellow tried to avoid the job by claiming that he had been sent to carry some much-needed apparatus to the pumping station at Turkey Creek so it was necessary to take his vehicle almost *ri et armis* and to stay with it until everything was collected and delivered to the launch. The writer can testify from personal observation that even in the small hours of the next morning the provisions thus procured were greatly appreciated by many hungry men.

What this repair work cost no one has yet figured. In buying the materials the engineers seldom asked the price, but when they found anything they needed, they ordered it sent to the site immediately, regardless of the cost of transportation.

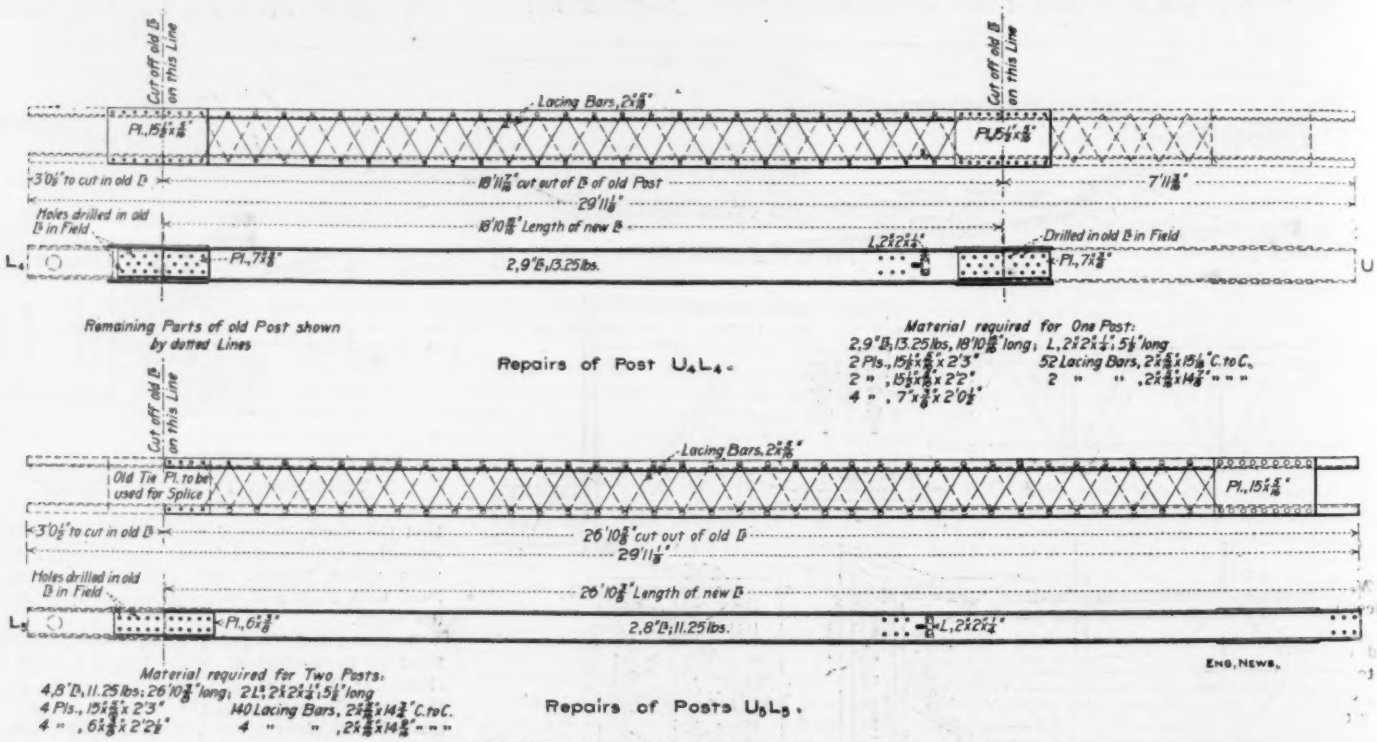

Cut off old Pl on this Line
Lacing Bars, 2½"
Pl., 15½"
Pl., 5½"
3'0½" to cut in old Pl
18'11⅛" cut out of Pl of old Post
29'11⅛"
7'11⅛"
Holes drilled in old Pl in Field
18'10⅝" Length of new Pl
L, 2½"
Drilled in old Pl in Field
Pl., 7⅛"
2,9"B,13.25 lbs.
Pl., 7⅛"
Remaining Parts of old Post shown by dotted Lines
Repairs of Post U4L4.
Material required for One Post:
2,9"B,13.25 lbs, 18'10⅝" long; L, 2½"
2 Pls., 15½"
2 " , 15½"
4 " , 7"
52 Lacing Bars, 2½"
2 " " , 2½"
Old Tie Pl. to be used for Splice
26'10⅝" cut out of old Pl
29'11⅛"
26'10⅝" Length of new Pl
Pl., 6⅛"
2,8"B,11.25 lbs.
L, 2½"
Material required for Two Posts:
4,8"B,11.25 lbs; 26'10⅝" long; 2L, 2½"
4 Pls., 15½"
4 " , 6⅛"
140 Lacing Bars, 2½"
4 " " , 2½"
Repairs of Posts U5L5.
ENG. NEWS.

FIG. 6. REPAIRS FOR INJURED POSTS OF STANDING SPAN.

were distributed with some regularity over the whole span. These upheld the load.

At the time of the accident Messrs. Ash and Cochrane were both on the west bank at some distance from the bridge. Seeing the water leaking from the partially plugged joints, Mr. Cochrane ran across the bridge to order it turned off, but found that this had already been done. By opening some valves the pipes were soon drained, and operations were resumed.

Had all the shims been in place so as to distribute the load over all the floor beams, the mishap would not have occurred, because the rope, though weak, had more than sufficient ultimate strength to carry the load when uniformly distributed.

The old pipes that were used leaked like sieves, and had to be plugged with wood. They still leak somewhat, but the amount of water thus lost is inconsiderable.

It did not take long to replace the broken suspenders and to strengthen those that had not been reinforced, so by noon on June 12 the water was turned on again, and the strained situation throughout the city was relieved.

From the preceding narrative it will be seen that the actual construction of the span occupied just one week, which, considering all the adverse conditions, is not a bad record. Everything from start to finish appeared to be against us. Materials were scarce, and proper ones were often not available; the nearest telephone of any account was half a mile away from our work; means of transportation were difficult to obtain; food for the workmen was hard to get; the men operating

to give instructions how to do certain manual work.

The securing of food for the men was no sinecure, as the writer well knows, this having been one of his special duties. Arrangements for the delivery of lunches were made both by telephone and by personal interviews, but no dependence could be placed on promises to supply food, owing to the great demand therefor throughout the entire city. As an illustration of this difficulty, on Sunday, June 7, about three o'clock in the afternoon the writer learned that the lunches he had ordered for noon had not been delivered, and that the supply of coffee for the early breakfast had been entirely inadequate. The men in consequence were hungry, and were feeling the need of their accustomed stimulant. The writer immediately took a launch for the city, appropriated a city official's horse and buggy, and drove to the principal hotels and restaurants, demanding good lunches, plenty of them, and an abundance of coffee, refusing to take "No" for an answer, and telling the proprietors that, as they would be paid their own price for everything, there was no possible excuse for refusal.

In the course of an hour there were ordered in this way nearly 400 good lunches and twenty gallons of excellent coffee, enough to keep everybody on the work satisfied until the next morning.

The next thing to be done was to get these supplies to the launch, so the writer attempted to secure a wagon, but everything on wheels was in service. After trying unsuccessfully four livery stables and an undertaker's establishment, and

Again, more men, twice over, were employed than would be used ordinarily on similar construction. Of course they were not handled economically, but there were usually plenty on hand whenever needed. Then, too, the night work was very expensive, not only because of the small output per man, as compared with day labor, but also on account of the higher wages paid.

Recognizing the city's dire need for the bridge, the engineers never counted cost, nor have they ever been criticised therefor, notwithstanding the appalling bills for such a small structure that the city was called upon to foot.

When the water was turned on, the engineers' work was by no means finished; for the old span had been strengthened only enough to make it safe temporarily. It was still necessary to put in one new floor beam, a number of new beam hangers, many new steel stringers, and an entirely new wooden floor; also to strengthen several injured floor beams and to repair the east portal bracing, which had been broken by the pressure from accumulated drift. This work was done more leisurely than the preceding, although no daylight hours were lost.

Soon after the water-works were again in operation it was decided to lay another pipe line over the bridge and to strengthen it for that purpose, the construction as before being placed wholly in the hands of the engineers. For this additional work we procured new main cables at St. Louis, and laid them alongside the others, carrying the new pipe on additional 6 × 8-in. floor beams placed above the existing cross-girders, as indicated on the large-scale sectional drawing.

In concluding this paper the writer desires to give credit in full where credit is due. To the great executive ability, strenuous exertions, and unfailing pluck of Mr. Ira G. Hedrick is due primarily the construction of the bridge in such a phenomenally short time and under such trying conditions. From the very start and until the water was turned on he labored day and night unceasingly, acting simultaneously as engineer, superintendent and foreman, and continually lending a hand at hauling upon ropes, or doing other manual labor.

Messrs. Ash and Cochrane deserve almost as much credit, for they, too, worked early and late up to the limit of human endurance, and seconded Mr. Hedrick most ably. Upon Mr. Ash fell a large portion of the disagreeable tasks, and he performed them most manfully. On Saturday afternoon, seeing him emerging from the cofferdam of the west anchorage, covered with mud, his good clothing ruined, haggard and with bloodshot eyes, the writer remarked that he was the toughest-looking specimen of a white man he had ever seen, and Mr. Ash could not contradict the statement.

Messrs, Allen and Hans von Unwerth attended to their share of the work faithfully and did it well.

The thanks of the entire city are due to the Stewart-Peck Sand Co., who most generously loaned us for the work several barges and one of their steamers until, as before stated, it ran aground, where it remained for a number of days.

To Mr. Robert W. Waddell, the writer's brother, and, until a short time before the flood City Engineer of Kansas City, Mo., are due the thanks of all concerned, for, without compensation and without being solicited, he devoted several days and nights to the forwarding of materials by means of the steamer and barges belonging to his business associates, the before-bentioned Stewart-Peck Sand Co. Special mention is made of this fact, as it is the first time that any credit has been given him for his exertions.

To Mr. Geo. Griffin, who furnished the skilled labor and the plant, and who gave his personal attention to the job, much credit is due.

Mr. W. W. Carter's services also must not pass unnoticed, for notwithstanding the fact that his years number more than three-score-and-ten, he labored early and late as foreman, and never failed to stand by the work till the night, when, fearing the old span was about to fall, he very properly ordered his men to leave the structure.

To the Riverside Iron Works the engineers' acknowledgments are due, in that they used every effort to furnish with the least possible delay all of the structural metal required for the new span and for the repairs to the old one.

And last, but by no means least, every credit must be given collectively to the brave and hard-working bridgemen, by means of whose willing, intelligent and long-continued exertions the work was accomplished. Many of them labored continuously as much as 36 hours, and it was not merely the large compensation that influenced them, for often when a man would remark, "I am dead beat and have to quit," one of us would reply, "Brace up and tackle it again for a few hours more; it is for the good of the city, and we cannot well spare you now," and he would then resume work willingly and cheerfully.

Throughout the entire construction the life of every man on the structure was in danger, and, what is more, *every bridgeman on the job knew it*; but they reasoned that, if the engineers were willing to risk their lives, the workmen could do no less than follow suit. It is true that we kept at all times a short distance below the bridge a skiff with two boatmen ready to pick up any one who might fall into the river, but they could have done very little in case of the collapse of the structure.

In an article like this it would be unbecoming to mention the efforts of His Honor, Mayor Reed, and of the Superintendent of the Water-Works, Mr. Goodwin, for these were the gentlemen by whom we were retained and to whom Kansas City is primarily indebted for extrication from its serious predicament; but it is perhaps permissible to state that whenever we called upon either of them to use his influence or authority on behalf of the work, it was accorded unhesitatingly and promptly.

Concerning the appearance and character of the repaired bridge, no apology need be made, although it is in no sense either handsome or first-class. To make it either under the circumstances would have been out of the question. It is doing its duty to-day satisfactorily, and all that its designers and builders now desire concerning it is that it be replaced within a reasonably short time either by a tunnel beneath the river bed or by a scientifically-designed and well-built bridge.

IMPROVEMENT OF RAILWAY TERMINAL FACILITIES AT ST. LOUIS, MO.

The city of St. Louis, which is served by some 20 railway companies, has for some time suffered serious trouble due to the congestion of freight traffic, the existing facilities and methods being inadequate for present conditions. The Business Men's League appointed a committee to consider the matter, and we are indebted to Mr. Wm. F. Saunders, Secretary of the League, for a copy of this committee's report, the principal features of which are abstracted below. It is shown that the tonnage carried across the river has increased from 3,802,000 tons in 1882 to 14,013,020 tons in 1902.

Your executive committee on terminal facilities has investigated the conditions affecting St. Louis commerce on the east and west banks of the Mississippi River, and found that the handling of freight was so closely interwoven with the management of passenger traffic, both to a large extent using the same facilities, that it was compelled to include conditions affecting the passenger traffic.

As a general rule, it was found the facilities for handling the traffic on both sides of the river are totally inadequate. The lack of sufficient yard room interferes with the free and rapid movement of cars, and lack of station room prevents the loose freight from being removed promptly or economically. The traffic has manifestly got beyond present capacity. The traffic is constant, and prompt movement of cars and freight is absolutely necessary, and must continue without interruption if the serious evils and annoyances contingent upon blockades are to be avoided.

To relieve the situation your committee recommends that the railway companies notify consignees immediately upon arrival of freight, and if it is not removed within a reasonable time, exercise their legal rights by storing goods in a public warehouse at owners' expense or risk, or charge demurrage, so that those who are diligent in the removal of their freight are not made to suffer by the indifferent or negligent.

The transportation companies on both sides of the river should be requested to make a more determined effort to clear their tracks, by bringing into use all available rolling stock in order to relieve the congestion now prevalent in most of the railway yards on both sides of the river. If the railways will promptly accept cars as they are ready to be delivered to them by connecting lines it will greatly help to overcome the trouble the commerce of St. Louis has been recently subjected to. Freight must be kept moving to destination in order to keep the lines free.

EAST SIDE FACILITIES.

In examining the situation on the east side of the river your committee found, in addition to insufficient terminals, methods in vogue that are crude and primitive, the outgrowth of conditions antedating the bridges. Trains of cars, partly loaded with freight for St. Louis and partly for points west of St. Louis, are emptied into inadequate sheds on the East Side, the freight being then picked over, partly loaded into wagons and partly reloaded into cars for destinations in St. Louis and railway connections for destinations westward.

The transfer across the river by wagon is a long, laborious haul, consuming considerable time and subject to many contingencies. If there is any delay in the unloading of wagons, either at the store of the merchant or at railway lines on the west bank of the river, freight accumulates in the East Side yards, and a congestion is the result. If the cars on the East Side can not be promptly unloaded, owing to the accumulation in the sheds, the tracks are soon blocked and the movement of freight becomes slow and difficult.

In the meantime, cars are held on the west bank of the river, and all traffic is impeded, interfering not alone with the St. Louis merchandise traffic, caused by the accumulation of freight intended for points beyond St. Louis, but also with outbound freight, and with the free and rapid handling of passenger trains, entailing poor service in all directions. This blocking of tracks also interferes with the free handling of coal, sometimes causing serious embarrassment to citizens of St. Louis.

IMPROVED FACILITIES RECOMMENDED.

After a careful examination of the conditions, and a personal examination of the terminal facilities on both sides of the river, your committee is of the unanimous opinion that the only solution of the question that will overcome, in a permanent way, the oft-recurring difficulties, is that there should be provided at the earliest possible date terminals and freight houses on the west bank of the river, in the city of St. Louis, within a reasonable hauling distance of the business districts of the city. These must be of ample size to promptly take care of all commerce to and from the territory east of St. Louis, and should, if possible, be located along the river front, in the vicinity of Washington Ave.

Freight houses, terminals and yards in North St. Louis and South St. Louis, and in the Mill Creek valley should be enlarged and in some cases reconstructed, to care for the constantly increasing traffic originating in St. Louis for transportation west, north and south.

Additional yard room should be provided for the storage of coal cars, both full and empty, and for the storing of empty passenger coaches.

A bridge across Ewing Ave. would facilitate the free movement of cars in and out of the yards necessary for coal, hay and similar commodities, and passenger coaches, contemplated in that vicinity.

An auxiliary station at the foot of Washington Ave., large enough to enable passengers to safely and comfortably leave and board trains without going to the Union station, would tend to permanently prevent the congestion of passenger traffic in the Union Station, and more especially during the St. Louis Exhibition.

The space in front of the Union Station should be enlarged, to permit of rapid and safe approach to and exit from the station.

There should also be a St. Louis bill of lading for all freight originating in St. Louis, or intended for St. Louis.

As to the availability of suitable passenger stations at or near the World's Fair grounds on railroads coming into the city from that quarter, your committee is advised that ample provision will be made.

COAL TRAFFIC.

St. Louis is almost entirely dependent for its coal supply on territory east of the Mississippi River. Over 5,000,000 tons came over the river in 1902 to meet the needs of the city of St. Louis. This means nearly 700 carloads, of 40,000 lbs. each, for every day.

Free and uninterrupted movement is absolutely necessary to prevent a coal famine, with its attendant hardships. Any interruption means a scarcity of coal, as present provisions permit of only a hand-to-mouth supply. There has frequently been great suffering and hardships resulting from even a short interruption to the free movement of this necessity of life. Exorbitant prices have been paid to keep plants in operation and great distress occasioned by reason of a scarcity of coal.

The Terminal Railroad Association has secured large tracts of land for the special purpose of holding cars carrying coal, hay, grain and similar commodities until they can be unloaded, and for storing empty cars until they can be hauled away, so as not to blockade the tracks or interfere with the free movement of trains. In order to get to these yards certain streets must be crossed. We recommend that proper ordinances necessary to enable the reaching of these storage yards be promptly granted.

The Association has also acquired property in North St. Louis, near the intersection of the Belt Line with Broadway, for railway yards, to expedite traffic in that section of the city. It is also double-tracking the belt lines, and expects to have the inner belt completed by the middle of October, and the outer belt by the first of the year. This will greatly facilitate movement of all traffic passing through this gateway.

DOUBLE TRACKING.

Many of the railways entering St. Louis have only single tracks. The committee is of the opinion, in view of the extraordinary traffic next year, and the constantly growing commerce having St. Louis for its center, that all roads entering St. Louis should be double-tracked for eight or ten miles from the city.

NEW APPROACHES.

To make the facilities available, it is necessary to have additional approaches to the bridge on the west side of the river, as the tunnel is used to its full capacity as far as safety will permit, and any trouble in the tunnel would make the bridge useless for railway purposes. In view of this, the committee has taken up the matter of the proposed elevated track along the river, the so-called loop.

This proposed loop runs from Washington Ave. to Market St., some 2,000 ft., over property acquired by the Terminal Railroad Association. It then follows the present elevated tracks some 2,200 ft. along the Levee, on columns in line with the present columns, and far enough apart for traffic to pass. It means widening the elevated tracks already there, having four tracks elevated instead of a double track. We do not believe this will prove objectionable, and the city would be compensated for any value granted in the shape of taxes derived from increased property values occasioned by building terminals on the west bank of the river, as contemplated by the Terminal Railroad Association. Your committee recom-

mends the granting of ordinances that will make this much-needed improvement possible.

To secure the free and uninterrupted connection by rail with the coal fields of Illinois and the entire territory east of us, your committee suggests that approaches to the bridges be elevated so that operations can not be interfered with by high water.

We would further recommend, to facilitate the handling of freight intended for St. Louis, that trains coming from the east, carrying freight intended for St. Louis and points west of St. Louis, should be broken in yards in East St. Louis. Cars containing St. Louis freight should be brought to St. Louis and unloaded into terminals on this side, while cars containing freight for points beyond St. Louis could be emptied at the sheds now in use on the East Side, and assorted there for delivery to westward connections, which can be promptly and economically done by means of the belt lines now approaching completion, which will connect all the railroads on the East Side with railroads on the west. When these proposed improvements are made the Terminal Railroad Association will have invested in and around St. Louis over $40,000,000.

In addition to the above the Terminal Association has a number of improvements now under consideration and in course of construction that will largely increase the present facilities of the city in the handling of passengers and freight, entailing altogether an expenditure from $7,000,000 to $10,000,000. To make the improvements contemplated and in course of construction available, service on the bridge now crossing the river must be largely increased.

FERRIES.

Your committee has also examined the present methods of transfer of freight by ferries. This service is capable of indefinite enlargement. It simply means a multiplication of units. The only interference that the free use of ferry transfer has is from ice, and we are informed that this has not happened more than fifteen days a year on an average in the last ten years.

To permit the use of the Eads bridge to its fullest capacity, additional outlets are necessary on this side of the river. The tunnel is now operated as far as safety will permit, to its full capacity.

PASSENGER SERVICE.

When the present Union passenger station was built it was considered ample for many years to come, and is today the largest in the world. It has been in use eight years, and is now entirely insufficient for the purpose intended. When the station was built the regular length of passenger trains was from five to seven cars, and only a few of the tracks were planned to handle longer trains. Two tracks for switching in and out of the station were considered ample. At present the railways are running passenger trains of 10 to 12 cars, and two tracks can no longer handle the traffic in and out of the station. Delays are of daily occurrence.

A new power house is in course of construction, and when completed the present power house will be removed, so that six tracks will be available to switch trains in and out of the station. This, together with the proposed extension of the train sheds, will accommodate long trains on all of the 32 tracks.

The handling of baggage at the Union Station is unsatisfactory, owing to crowded conditions. An underground street or subway, 100 ft. wide, extending from 18th to 20th St., is now in process of construction, and will facilitate the free and rapid handling of baggage, mail and express underground, and do away with the present interference on the tracks of the station. A passageway connecting this underground street with the general ticket and baggage offices will allow the checking of baggage in the waiting room, near the ticket offices, where provisions will be made.

When the present plans to extend the Union Station are completed, the "midway" will be enlarged to about double its present size, giving room for the handling of 50,000 to 60,000 passengers per hour.

Property has been purchased for yard room to store passenger coaches when empty and hold them out of the way of travel until again needed.

OTHER TERMINALS.

Visiting the various terminals around the city of St. Louis, your committee found a large number of industries in the towns of East St. Louis, Venice, Madison, Granite City and scattered along the east bank of the river that were formerly in St. Louis and are the outgrowth of St. Louis business. The fact that quite a number of important St. Louis industries have moved to the east side of the river has been the subject of more or less discussion. Many reasons have been assigned as to the cause of these removals, the bridge arbitrary, the higher cost of coal and the difference in cost of water have been quoted.

The raw material used by these manufacturing plants is low-class freight, and is entirely handled in carload lots, and the cost of transfer across the river is not an important item in calculating the cost of the finished product. It costs 30 cts. per ton to switch coal from East St. Louis to industries on tracks in St. Louis, against 10 cts. per ton for switching coal to East St. Louis industries not on the main lines. The difference of 20 cts. per ton to the largest concerns on the east bank of the river will not amount to more than a few thousand dollars per year.

The difference in the cost of water, though quite an item, is not of sufficient importance in deciding so important a matter as the location of an industry, and it appears that all these matters in themselves are not sufficient to overcome the advantages that would attach to a location in St. Louis, as here they would be in close proximity to the homes of their employes, as the distance their employes must cover every day, and the cost of transportation, is an element to be considered, and must be covered by extra pay for such loss of time and extra cost to reach the places of employment.

St. Louis should treat applications for railroad connections with greater consideration. Privileges for switches should be granted without unreasonable sacrifices. The water rates should be reduced. The charge for switching coal should be put at the minimum possible cost.

In reply to the recommendations and suggestions contained in this report, the Terminal Railroad Association sent the following communication to the committee:

The Terminal Railroad Association executive committee will do all in its power to provide a St. Louis bill of lading for all traffic intended for St. Louis or originating in St. Louis. This, however, is a question that will have to be submitted to each of the proprietary lines, and in some cases to their connections beyond. We believe, however, it can be arranged.

The Association will provide freight facilities on the west side of the river, increasing same from time to time, as needed, to the extent of handling on the west side of the river the traffic which the merchants prefer to so receive and forward.

The Association will construct a suitable passenger station at Washington Ave. and the Levee, or in that vicinity. The exact location of the station will depend upon the arrangement of the so-called loop tracks.

The executive committee of the Terminal Railroad Association cannot appropriate any funds toward acquiring property to be used as a park opposite the Union Station. It agrees, however, to recommend to the board of directors of the Association that they co-operate with the city of St. Louis toward the acquirement of this property for the purposes you suggest.

We can not increase passenger facilities or make proper provisions for handling baggage, mail and express matter, nor can the freight terminals on the west bank of the river be constructed, nor the passenger station at the foot of Washington Ave. built, unless the proper ordinances are granted to make these improvements possible; nor can we reach the yard facilities needed to switch and handle passenger, freight and coal cars unless it is possible to have access to the property we have already purchased for these purposes.

As to the facilities for handling St. Louis traffic on the west side of the river, we will endeavor to furnish these facilities just as fast as they are required and locate them so as to give the best possible service. On account of the large volume of business, it is not believed one station would answer requirements, but it could be arranged to have several stations located in different parts of the city, where they would be most accessible to the business interests in the different localities.

MUNICIPAL ELECTRIC LIGHT PLANT AT ORILLIA, ONT.

A successful municipal electric lighting plant at Orillia, Ont., is described in "The Canadian Engineer" for September. Power is taken from the Severn River at a point 19½ miles distant and is transmitted at 22,000 volts' pressure to a substation at Orillia, where it is reduced to 2,000 volts. There are about 5,000 incandescent lamps in use and the streets are lighted by 50 arc lamps. The town water-works station requires about 100 HP. of current and about 425 HP. is furnished to local industries. The lighting rates are 25 cts. per month for each 16-c. p. incandescent lamp in residences, and 35 cts. per month in stores, halls, hotels, etc. For metered services the rate is 13 cts per KW. hour, and on either rate 20% is discounted for prompt payment of bills. For motors the charge is about $15 per HP. per annum. The annual receipts are about $9,700 for lights and about $6,500 for power. This is sufficient to pay the operating expenses and repairs and the interest on the cost of the plant, and leave a balance of $600 to $1,000. It will be noted that depreciation is not included in the above; but on the other hand the town gets its street lighting and lights in its public buildings and power for the water-works pumping station free of cost. The population of Orillia is about 5,000.

A FALL OF ROCK in the Rapid Transit Railway tunnel under Washington Heights on Oct. 24 killed ten workmen and injured five others. This tunnel is the longest deep tunnel on the line and extends from 158th St. to Fort George at about 196th St. The accident occurred at a point about 1,000 ft. south of the Fort George portal and consisted in the fall of a wedge-shaped piece of rock from the roof. This block of rock was about 44 ft. long and the roof was just about to be timbered when the accident occurred. A full description of this tunnel work was published in Engineering News of June 11, 1903.

A LOCOMOTIVE EXPLODED at Elkins, W. Va., on the West Virginia Central & Pittsburg Ry., on Oct. 21. Four persons were killed. The cause of the explosion is not known.

THE SLOW SAND FILTRATION PLANT at Washington, D. C., will be equipped with 36-in. centrifugal pumps of the triple-vane impeller type, direct-connected to Harrisburg four-valve tandem-compound condensing engines. Each pump will have a capacity of 30,000 gallons per minute, or over 43,000,000 gallons a day, under a total head of 35 ft. The contract for the pumps and engines has been awarded to the H. R. Worthington Co., of New York City. Lieut.-Col. A. M. Miller, M. Am. Soc. C. E., is in charge of the new filter and Mr. Allen Hazen, M. Am. Soc. C. E., is consulting engineer.

DEATHS FROM TYPHOID FEVER in Michigan for the five years, 1898 to 1902, averaged 26.9 per 100,000 for the entire state, 29.8 for the incorporated cities, and 25.0 for the population outside of such cities. The highest typhoid death rate for a group of cities was 34.6 for places between 10,000 and 25,000. The low rate of 21.4 in Detroit brought down the average for the larger cities. Excluding Alpena and Manistee, whose mortality statistics have been rejected as unreliable by the U. S. Census Office, the typhoid death rate in the remaining cities of 10,000 population and upwards is given as follows, in the September number of the Michigan "Monthly Bulletin of Vital Statistics:"

	Mean death rate from typhoid fever, 1898-1902.
Cities of Low Mortality.	
Ann Arbor	16.5
Detroit	21.4
Muskegon	24.0
Saginaw	25.0
West Bay City	25.9
Cities of about Average Mortality:	
Ishpeming	27.2
Flint	27.5
Kalamazoo	27.9
Bay City	28.2
Lansing	29.1
Average mortality, all cities over 10,000	29.1
Cities Above Average Mortality:	
Port Huron	38.6
Grand Rapids	39.1
Battle Creek	39.9
Marquette	43.7
Jackson	44.3
Cities of High Mortality:	
Menominee	74.9
Sault Ste. Marie	93.0

For the first nine months of 1903, the total number of deaths from typhoid in Menominee and Sault Ste. Marie "is very close to the total for the five-year period" for all cities of the state the total of typhoid deaths is slightly below the average. For the District of Columbia and the nine "Registration States" (those with acceptably accurate vital statistics) the death rate from typhoid fever in 1900, according to the U. S. Census, was 25.4 per 100,000 for the total population; 25.3 for the city and 25.5 for the rural population. The same figures for 1890, omitting Maine and Michigan, which were not then classed as registration states, were: 36.0, total; 39, cities; 31.4, rural. Thus, on the face of it, the disparity between the rural and urban death rates from typhoid fever was eliminated in ten years, but doubtless it would be wise to be cautious in drawing inferences from these figures alone.

THE LARGEST SINGLE-STREAM IMPULSE WATER-wheels ever built are probably the two wheels recently installed in the plant of the Valley Counties Power Co., on Butte Creek, near Nimshew, Cal. The wheels are each of 3,700 HP. capacity, at a normal speed of 240 r. p. m., and operate under a head of 1,531 ft. of water. The pipeline, 6,200 ft. long, is of 30 to 28½ ins. diameter; a Y within the power house leads to the two wheels. Each power unit consists of a Stanley alternating-current generator and an Abner Doble impulse wheel, mounted on a hollow-forged nickel-steel shaft. The shaft rests in only two bearings, the waterwheel being overhung while the generator is between the bearings. The revolving part of each unit weighs over 40 tons. The governing is by combination deflecting and needle nozzle; the deflecting is done automatically by the governor while the needle is set, by hand, every hour for the maximum power demand to be expected during that period. The current produced at this plant feeds into the famous transmission line of the Bay Counties Power Co.